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(54) **SHEET SHEARING METHOD**
SCHERVERFAHREN FÜR BLECH
PROCÉDÉ DE CISAILLEMENT DE TÔLE

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Description

TECHNICAL FIELD

[0001] The present invention relates to a method of shearing a thin plate, and more specifically to a method for forming a product by shearing a thin plate with a thickness of about 0.5 mm or less, which is made of a metal or prepared by laminating one or more non-metal layers on one or respective ones of opposite surfaces of a metal layer.

BACKGROUND ART

[0002] As a technique for forming a product from a thin plate, a method of punching (blanking) a thin plate using a forming tool (punch and die) is most common.

[0003] In the punching (blanking) method, the workpiece plate is subjected to shearing by placing a workpiece plate on a die having a punch hole, and moving a punch disposed just above the punch hole downwardly to allow a distal end of the punch to be fitted into the punch hole. In some cases, the punch and the die are disposed upside down, i.e., the punch is disposed just below the die, and the die is moved instead of the punch.

[0004] In regard to conditions for the punching, considerable researches have heretofore been made. For example, the following Non-Patent Document 1 discloses an adequate relationship between a thickness of a workpiece plate, and a gap between a punch and a die (punch hole) for punching the workpiece plate (the gap will hereinafter be referred to simply as "clearance"). In the Non-Patent Document 1, an adequate clearance is described as about 5 to 10% of the thickness of the workpiece plate.

[0005] According to this relationship between the thickness of the workpiece plate and the clearance, when the workpiece plate has a thickness of 1 mm, the clearance is in the range of about 50 to 100 μm . As long as the clearance is such a value, it is easy to fabricate a forming tool, etc. However, when the workpiece plate has a smaller thickness, e.g., a thickness of 20 μm , the adequate clearance is reduced to 1 to 2 μm , so that a high level of fabrication technique, such as precision machining, is required for a forming tool, which leads to a problem of an increase in cost.

[0006] Moreover, a punching operation using a forming tool fabricated to have a narrowed clearance involves other problems. One problem is a reduction in usable life of the forming tool due to wear of the punch and the die. Specifically, a narrower clearance leads to a higher frequency of contact between the punch and the die in elastic deformation ranges thereof, which accelerates wear thereof. Further, if the punch and the die are deformed beyond the elastic deformation ranges during the contact therebetween, a problem of chipping will also occur.

[0007] Another major problem is a problem with debris to be generated from a workpiece plate during punching.

This problem becomes prominent when the workpiece plate is a laminated plate comprised of a metal layer and a non-metal layer. Debris generated from a workpiece plate is trapped between the punch and the die, which causes various problems, such as a problem of an increase in force required for punching, and a problem of an increase in frequency of cleaning required for the punch and the die. Moreover, the debris is likely to cause breakage of the forming tool.

[0008] The conventional punching method has another problem. Specifically, along with punching of a workpiece plate, particularly a metal plate, depending on its compatibility with a forming tool, adhesion of the workpiece plate is likely to occur in a punch. It is possible to prevent the adhesion problem to some extent by coating a punch and a die with ceramics, DLC (Diamond-Like Carbon) or the like. However, in a forming tool having a narrow clearance, only a temporary effect can be obtained because large wear occurs in a punch and a die due to a sliding movement therebetween.

[0009] Still another problem is deterioration in quality of an outer edge of a punched-out portion of the workpiece plate (product portion). This is because, after punching the workpiece plate, the punched-out portion is moved to a dead center position of the punch while rubbing against an inner surface of the die, i.e., placed in a rubbing state through until it is separated from the die.

[0010] As above, in shearing based on the conventional punching method, various problems occurs, particularly, when a workpiece plate has a small thickness.

PRIOR ART DOCUMENTS

[NON-PATENT DOCUMENTS]

[0011] Non-Patent Document 1: A. Hashimoto, "Press Operations & Die Machining Methods New Edition", 7th Edition, Nikkan Kogyo Shimbun, Ltd., April 30, 1975, p 35

SUMMARY OF THE INVENTION

[PROBLEM TO BE SOLVED BY THE INVENTION]

[0012] In view of the above various problems involved in shearing based on the conventional punching method, it is an object of the present invention to provide a method capable of shearing a thin plate with high quality over a long period of time, and significantly excellently shearing a thin plate based on a low-cost forming tool and a low-cost process, without the necessity to subject a forming tool for use in the shearing to precision machining.

[MEANS FOR SOLVING THE PROBLEM]

[0013] Through various researches on shearing of thin plates, the inventor found that, in a thin plate prepared by laminating one or more non-metal layers on one or respective ones of opposite surfaces of a metal layer,

the thin plate is fully sheared before a punch penetrates through the thin plate and becomes fitted into a shearing hole of a die.

[0014] The present invention has been made based on the above finding. Specifically, the present invention provides a method of shearing a thin plate prepared by laminating one or more non-metal layers on one or respective ones of opposite surfaces of a metal layer. The method comprises: placing the thin plate between a punch and a die having a shearing hole; and relatively moving the punch toward and with respect to the shearing hole to thereby shear the thin plate, wherein the relative movement of the punch is stopped to complete the shearing, before the punch penetrates through the thin plate and becomes fitted into the shearing hole.

[0015] As above, in the present invention, the punch is not fitted into the die, so that it is not necessary to severely adjust a clearance as in the conventional punching method designed to allow the punch to be fitted into the die. Thus, the clearance may be set to a zero clearance, or a minus clearance in which an outer diameter of the punch is set to be greater than an inner diameter of the die, as well as an usual plus clearance. In other words, in the present invention, it is not necessary to severely adjust a clearance based on precision machining of a forming tool (punch and die), so that it becomes possible to easily fabricate the forming tool and reduce a fabrication cost of the forming tool.

[0016] In addition, based on the feature that the punch is not fitted into the die, each of the punch and the die becomes less likely to be worn, which provides extended usable life of the forming tool. Further, a displacement of a sheared portion of a workpiece plate is reduced, and thereby an amount of debris to be generated is reduced. The conventional method also has a problem that, along with a vertical movement of the punch, a metal portion of a workpiece plate in contact with the punch adheres to the punch. It is difficult to remove the adhered metal component by rubbing or scraping, or using chemicals, a surface of the punch will have scars, or higher roughness, or alteration due to corrosion. Moreover, the adhesion phenomenon occurs after 100 shots at the latest, or after only 5 to 10 shots at the earliest. In contrast, in the method of the present invention, the shearing can be performed without bringing the punch into direct contact with a metal portion of a workpiece plate, so that it becomes possible to prevent the workpiece plate from adhering to the punch.

[0017] Thus, a shearing state can be excellently maintained, and the thin plate can be sheared with high quality. As for a forming tool, there is no need to fabricate a forming tool with a maximally narrowed clearance which causes difficulty in fabrication and leads to a high cost, and therefore there is no need to take a high cost for fabrication of a forming tool.

[0018] Meanwhile, in the technical field of punching (blanking), there has been known a method of punching

a workpiece plate by subjecting the workpiece plate to half blanking in one direction, and then subjecting the workpiece plate to reversed blanking, instead of punching the workpiece plate by a single punching operation (see, for example, JP 2004-167547A and JP 2001-300647A). The shearing method of the present invention is essentially different from the conventional half blanking/reversed blanking technique, in that the shearing method is designed to fully shear a workpiece plate by a single shearing operation.

[0019] Preferably, in the present invention, the punch is stopped at a position corresponding to a depth in the thin plate which is equal to or greater than a thickness of the metal layer and equal to or less than a total thickness of the one or more non-metal layers. If the depth corresponding to the stop position of the punch is less than the thickness of the metal layer, a possibility to fail to complete the shearing of the thin plate will be increased. Further, if the depth is greater than the total thickness of the one or more non-metal layers, chipping in the punch and the die, an increase in amount of debris and/or adhesion of a metal component of the thin plate to the punch will occur, which is likely to cause difficulty in sufficiently obtain the effects of the present invention.

[0020] Through experimental tests conducted by the inventor, it has been found that the shearing method of the present invention can also be applied to a thin plate stack formed by stacking a plurality of the thin plates on each other. In this case, the thin plate stack is placed between the punch and the die, and the relative movement of the punch is stopped to complete the shearing, before the punch penetrates through the thin plate stack and becomes fitted into the shearing hole. In this manner, the plurality of thin plates can be simultaneously sheared to provide enhanced productivity. In cases where a plurality of thin plates are originally used in the form of a laminated structure as in an electrode plate for a lithium-ion battery, etc., a step of laminating respective sheared portions of the thin plates can be omitted by simultaneously shearing the laminated thin plates. However, the number of the thin plates capable of being simultaneously sheared is about 10 at a maximum, in view of quality of a cut (sheared) surface of a workpiece plate. If the number is excessively increased, the cut surface will be gradually roughened, so that it becomes difficult to use resulting products in the field requiring high quality. Preferably, in cases where a thin plate stack formed by stacking a plurality of the thin plates on each other is simultaneously sheared, the punch is stopped at a position corresponding a depth in the thin plate stack which is equal to or greater than a total thickness of the metal layers of the thin plate stack (a sum of respective thicknesses of the metal layers in the plurality of stacked thin plates) and equal to or less than a total thickness of the non-metal layers of the thin plate stack (a sum of respective thicknesses of the non-metal layers in the plurality of stacked thin plates).

[0021] In addition to the shearing using the punch and

the die, the shearing method of the present invention can also be applied to shearing using a die cutter and an anvil roll. Specifically, the present invention provides a method of shearing a thin plate prepared by laminating one or more non-metal layers on one or respective ones of opposite surfaces of a metal layer. The method comprises: inserting the thin plate between a die cutter provided with a convex push-cutting blade on a surface thereof, and an anvil roll provided with a shearing recess at a position corresponding to the convex push-cutting blade; and rotating and pressing the convex push-cutting blade of the die cutter toward the shearing recess of the anvil roll to thereby shear the thin plate, wherein the thin plate is sheared without causing the convex push-cutting blade of the die cutter to penetrate through the thin plate and become fitted into the shearing recess of the anvil roll. This shearing method also provides the same effects as those of the shearing using the punch and the die. In other words, the thin plate is fully sheared before the convex push-cutting blade of the die cutter penetrates through the thin plate and become fitted into the shearing recess of the anvil roll.

[0022] Preferably, in the shearing method using the die cutter and the anvil roll, the convex push-cutting blade of the die cutter is thrust to a position corresponding to a depth in the thin plate which is equal to or greater than the thickness of the metal layer and equal to or less than the total thickness of the one or more non-metal layers.

[0023] Further, in order to more reliably shear the thin plate (i.e., workpiece plate) in the shearing method using the die cutter and the anvil roll, an intermediate plate having at least one non-metal layer may be inserted between the die cutter and the thin plate. Based on using the intermediate plate in the above manner, the thin plate can be more reliably sheared by a pressing effect arising from plastic flow of the intermediate plate. Preferably, in this case, the convex push-cutting blade of the die cutter is thrust to a position corresponding to a depth in a combination of the intermediate plate and the thin plate which is equal to or greater than a total thickness of the metal layers of the thin plate and equal to or less than a total thickness of the one or more non-metal layers of the thin plate and the intermediate plate.

[0024] In the present invention, in place of the die cutter provided with the convex push-cutting blade on a surface thereof, a press roll devoid of the convex push-cutting blade may be used. Specifically, the present invention provides a method of shearing a thin plate prepared by laminating one or more non-metal layers on one or respective ones of opposite surfaces of a metal layer. The method comprises: inserting the thin plate between a press roll, and an anvil roll provided with a shearing recess; and rotating the press roll to press the thin plate toward the shearing recess of the anvil roll to thereby shear the thin plate, wherein an intermediate plate having at least one non-metal layer is inserted between the thin plate and the die cutter, and the thin plate is sheared without pressing the thin plate into the shearing recess

of the anvil roll beyond a thickness of the thin plate. In this shearing method, the thin plate is fully sheared before the thin plate is fully pressed into the shearing recess of the anvil roll. Preferably, in this shearing method, the thin plate is pressed to a position corresponding to a depth in the shearing recess of the anvil roll which is equal to or greater than a thickness of the metal layer and equal to or less than a total thickness of the one or more non-metal layers of the thin plate.

[0025] The shearing method using the die cutter or press roll and the anvil roll, a thin plate stack formed by stacking a plurality of the thin plates on each other may be inserted between the die cutter or press roll and the anvil roll, to simultaneously shear the plurality of stacked thin plates. Specifically, in the shearing method using the die cutter and the anvil roll, the thin plate stack is inserted between the die cutter and the anvil roll, and all of the thin plates are sheared without causing the convex push-cutting blade of the die cutter to penetrate through the thin plate stack and become fitted into the shearing recess of the anvil roll. Preferably, in this case, the convex push-cutting blade of the die cutter is thrust to a position corresponding to a depth in the thin plate stack which is equal to or greater than a total thickness of the metal layers of the thin plate stack and equal to or less than a total thickness of the non-metal layers of the thin plate stack. When the intermediate plate is used in combination, it is preferable that the convex push-cutting blade of the die cutter is thrust to a position corresponding to a depth in a combination of the intermediate plate and the thin plate stack which is equal to or greater than a total thickness of the metal layers of the thin plate stack and equal to or less than a total thickness of the non-metal layers of the thin plate stack and the intermediate plate.

[0026] On the other hand, in the shearing method using the press roll and the anvil roll, the thin plate stack is inserted between the press roll and the anvil roll, and the intermediate plate having at least one non-metal layer is inserted between the thin plate stack and the press roll, whereafter the thin plate stack is sheared without pressing the thin plate stack into the shearing recess of the anvil roll beyond a thickness of the thin plate stack. Preferably, in this case, the thin plate stack is pressed to a position corresponding to a depth in the shearing recess of the anvil roll which is equal to or greater than a total thickness of the metal layers of the thin plate stack and equal to or less than a total thickness of the non-metal layers of the thin plate stack.

[0027] In the present invention, in the shearing method using the press roll and the anvil roll, a surface of the press roll may be coated with a layer including at least one non-metal layer. Specifically, the present invention provides a method of shearing a thin plate which is made of a metal or prepared by laminating one or more non-metal layers on one or respective ones of opposite surfaces of a metal layer. The method comprises: inserting the thin plate between a press roll having a surface coat-

ed with a layer including at least one non-metal layer, and an anvil roll provided with a shearing recess; and rotating the press roll to press the thin plate toward the shearing recess of the anvil roll to thereby shear the thin plate, wherein the thin plate is sheared without pressing the thin plate into the shearing recess of the anvil roll beyond a thickness of the thin plate. Preferably, in this shearing method, the thin plate is pressed to a position corresponding to a depth in the shearing recess of the anvil roll which is equal to or greater than a thickness of the metal layer and equal to or less than a total thickness of the one or more non-metal layers of the thin plate. In this shearing method, when a plurality of the thin plates are stacked on each other to form a thin plate stack, and the thin plate stack is inserted between the press roll and the anvil roll and sheared, the thin plate stack is sheared without pressing the thin plate stack into the shearing recess of the anvil roll beyond a thickness of the thin plate stack. Preferably, the thin plate stack is pressed to a position corresponding to a depth in the shearing recess of the anvil roll which is equal to or greater than a total thickness of the metal layers of the thin plate stack and equal to or less than a total thickness of the non-metal layers of the thin plate stack.

[0028] As mentioned above, the shearing method of the present invention is applied to a thin plate prepared by laminating one or more non-metal layers on one or respective ones of opposite surfaces of a metal layer. However, the shearing method of the present invention may also be applied to a thin plate made of a metal. Specifically, in a shearing method using a punch and a die having a shearing hole, a thin plate made of a metal is placed between the punch and the die, and the punch is relatively moved toward and with respect to the shearing hole to thereby shear the thin plate, wherein an intermediate plate having at least one non-metal layer is placed between the thin plate and the punch, and the relative movement of the punch is stopped to complete the shearing of the metal plate, before the punch penetrates through the intermediate plate. Preferably, in this case, the relative movement of the punch is stopped at a position corresponding to a depth in a combination of the thin plate and the intermediate plate which is equal to or greater than a thickness of the thin plate and equal to or less than a thickness of the intermediate plate.

[0029] In a shearing method using a die cutter provided with a convex push-cutting blade on a surface thereof and an anvil roll provided with a shearing recess at a position corresponding to the convex push-cutting blade, a thin plate made of a metal is inserted between the die cutter and the anvil roll, and the convex push-cutting blade of the die cutter is rotated and pressed toward the shearing recess of the anvil roll to thereby shear the thin plate, wherein an intermediate plate having at least one non-metal layer is inserted between the thin plate and the die cutter, and the thin plate is sheared without causing the convex push-cutting blade of the die cutter to penetrate through the intermediate plate and become fitted

into the shearing recess of the anvil roll. Preferably, in this case, the convex push-cutting blade of the die cutter is thrust to a position corresponding to a depth in a combination of the thin plate and the intermediate plate which is equal to or greater than a thickness of the thin plate and equal to or less than a thickness of the intermediate plate.

[0030] In a shearing method using a press roll and an anvil roll provided with a shearing recess, a thin plate made of a metal is inserted between the press roll and the anvil roll, and the press roll is rotated to press the thin plate toward the shearing recess of the anvil roll to thereby shear the thin plate, wherein an intermediate plate having at least one non-metal layer is inserted between the thin plate and the die cutter, and the thin plate is sheared without pressing the thin plate into the shearing recess of the anvil roll beyond a thickness of the thin plate. In a shearing method using a press roll having a surface coated with a layer including at least one non-metal layer, and an anvil roll provided with a shearing recess, a thin plate made of metal is inserted between the press roll and the anvil roll, and the press roll is rotated to press the thin plate toward the shearing recess of the anvil roll to thereby shear the thin plate, wherein the thin plate is sheared without pressing the thin plate into the shearing recess of the anvil roll beyond a thickness of the thin plate.

[0031] Among the above shearing methods of the present invention, in the shearing method using the die cutter or press roll, the anvil roll and the intermediate plate, in order to allow the intermediate plate to be repeatedly used, the intermediate plate may be formed in an endless configuration, wherein the intermediate plate is inserted between the die cutter or press roll and the thin plate or thin plate stack and then passed and pressed between a pair of rolls, whereafter the intermediate plate is re-inserted between the die cutter or press roll and the thin plate or thin plate stack.

[0032] In the present invention, the anvil roll may be formed such that the shearing recess thereof has a peripheral edge region made of a material having hardness greater than that of the remaining region of the anvil roll. This makes it possible to reliably perform the shearing while preventing chipping or the like from occurring in the peripheral edge region of the shearing recess which is a shearing area.

[0033] Further, the anvil roll may have at least two cut-outs provided at respective positions before and after the shearing recess in a rotation direction thereof, with a given distance from the shearing recess. This makes it possible to prevent the thin plate or thin plate stack from being excessively pressed at respective positions before and after the shearing recess and damaged.

[EFFECT OF THE INVENTION]

[0034] In a method of shearing a thin plate which is made of a metal or prepared by laminating one or more

non-metal layers on one or respective ones of opposite surfaces of a metal layer, the present invention makes it possible to shear the thin plate with high quality over a long period of time while allowing a forming tool to be fabricated at relatively low cost, and therefore perform the shearing of the thin plate with high quality at low cost.

BRIEF DESCRIPTION OF THE DRAWINGS

[0035]

FIGS. 1(a) and 1(b) illustrate basic steps of a shearing method according to a first embodiment of the present invention.

FIGS. 2(a) and 2(b) illustrate a shearing method according to a second embodiment of the present invention.

FIGS. 3(a) and 3(b) illustrate a shearing method according to a third embodiment of the present invention.

FIG. 4 illustrates a shearing method according to a fourth embodiment of the present invention.

FIG. 5 illustrates one modification of the embodiment in FIG. 4.

FIG. 6 illustrates a shearing method according to a fifth embodiment of the present invention.

FIGS. 7(a) to 7(f) illustrate various examples of a shape of a convex push-cutting blade of a die cutter, wherein FIG. 7(b), FIG. 7(d) and FIG. 7(f) are sectional views taken along the line A-A in FIG. 7(a), the line B-B in FIG. 7(c) and the line C-C in FIG. 7(e), respectively.

FIG. 8 illustrates a shearing method according to a sixth embodiment of the present invention.

FIG. 9 illustrates one modification of the embodiment in FIG. 8.

FIG. 10 illustrates a shearing method according to a seventh embodiment of the present invention.

FIG. 11 illustrates a shearing method according to an eighth embodiment of the present invention.

FIG. 12 illustrates a shearing method according to a ninth embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0036] With reference to the drawings, the present invention will now be described based on various embodiments thereof.

[FIRST EMBODIMENT]

[0037] FIGS. 1(a) and 1(b) are explanatory diagrams showing basis steps of a shearing method according to a first embodiment of the present invention.

In the first embodiment illustrated in FIG. 1, a workpiece plate 1 is an electrode plate for a lithium-ion battery, which is prepared by laminating two active material layers (non-metal layers) 1b on respective ones of opposite surfaces

of a metal layer 1a made of copper or aluminum. The metal layer 1a has a thickness of 20 μm , and each of the non-metal layers 1b has a thickness of 80 μm . Thus, a thickness of the workpiece plate 1 is 180 μm in total.

5 [0038] As shown in FIG. 1(a), the workpiece plate 1 is placed on and fixed to a die 2 having a shearing hole 2a. Then, as shown in FIG. 1(b), a punch 3 disposed just above the shearing hole 2a is moved downwardly to shear the workpiece plate 1.

10 [0039] In the first embodiment, the punch 3 is stopped at a position away from an initial contact position between the punch 3 and an upper surface of the workpiece plate 1 by 30 μm , i.e. at a timing when the punch 3 is moved downwardly (in a depthwise direction of the workpiece plate 1) to a position corresponding to a depth equal to 17% of the thickness of the workpiece plate 1. In a test carried out under the above conditions, it was verified that the workpiece plate 1 is fully sheared. A sheared product portion of the workpiece plate 1 can be easily extracted by pushing or sucking it from thereabove or therebelow. In the first embodiment, a clearance between the punch and the die is set to 10 μm . The clearance of 10 μm is a value free of particular difficulty in fabricating a forming tool.

25 [0040] As above, in the first embodiment, the workpiece plate 1 is sheared without bringing the punch 3 into direct contact with the metal layer 1a located in a central region of the workpiece plate 1, so that it becomes possible to prevent a metal component of the metal layer 1a from adhering to the punch 3 and exerting adverse effects on the shearing. In addition, a problem of roughening of a sheared surface never occurs.

30 [0041] Although the first embodiment illustrated in FIG. 1 shows one example where the workpiece plate 1 is sheared which is prepared by laminating the two non-metal layers 1b on respective ones of the opposite surfaces of the metal layer 1a, it is also possible to shear a workpiece plate prepared by laminating one non-metal layer on one of opposite surfaces of a metal layer, in the same manner. Preferably, in this case, the workpiece plate is placed such that the non-metal layer is located on an upper side thereof so as to allow the punch to be brought into contact with the non-metal layer.

35 [0042] In the first embodiment illustrated in FIG. 1, the punch 3 is disposed just above the die 2. Alternatively, the punch and the die are disposed upside down, i.e., the punch is disposed just below the die. In the first embodiment illustrated in FIG. 1, the punch 3 is adapted to be moved vertically. Alternatively, the die 2 may be adapted to be moved vertically.

[SECOND EMBODIMENT]

45 [0043] FIG. 2 illustrates a shearing method according to a second embodiment of the present invention. The second embodiment is one example where a plurality of workpiece plates are stacked on each other to form a workpiece plate stack, and then sheared.

[0044] In the second embodiment, each of eight workpiece plates 1 is an electrode plate for a lithium-ion battery, which has a thickness of 180 μm , as with the first embodiment, and they are stacked on each other vertically. Thus, a total thickness of the stacked workpiece plates 1, i.e., workpiece plate stack, is 1.44 mm.

[0045] In the second embodiment, the punch 3 is stopped at a position away from an initial contact position between the punch 3 and an upper surface of the workpiece plate stack (eight stacked workpiece plates 1) by 200 μm , i.e. at a timing when the punch 3 is moved downwardly (in a depthwise direction of the workpiece plate stack) to a position corresponding to a depth equal to 14% of the thickness of the workpiece plate stack. In a test carried out under the above conditions, it was verified that all of the eight workpiece plates 1 are fully sheared.

[THIRD EMBODIMENT]

[0046] FIG. 3 illustrates a shearing method according to a third embodiment of the present invention. The third embodiment is one example where a thin plate made of a metal is sheared using a punch and a die.

[0047] As shown in FIG. 3(a), a thin plate made of a metal, as a workpiece plate 7, is placed on a die 2, and then an intermediate plate 8 having at least one non-metal layer is placed on the workpiece plate 7. In the third embodiment, the workpiece plate 7 is comprised of a titanium plate having a thickness of 20 μm , and the intermediate plate 8 is comprised of a polypropylene plate having a thickness of 150 μm . As a material of the intermediate plate 8, a non-metal layer may be used which is made of one selected from the group consisting of acrylic resin, PET, polycarbonate, bakelite, plastic, fluororesin, epoxy resin, polyurethane, polyvinyl chloride, polyamide, polyethylene, vinyl chloride, hard rubber, paper, glass plate, asphalt and synthetic fiber, as well as polypropylene. Further, a laminated material comprised of two or more of the non-metal layers or a laminated material comprised of the non-metal layer and a metal layer may be used.

[0048] Then, as shown in FIG. 3(b), a punch 3 disposed just above a shearing hole 2a of the die is moved downwardly to shear the workpiece plate 7.

[0049] In the third embodiment, the punch 3 is stopped at a position away from an initial contact position between the punch 3 and an upper surface of the intermediate plate 8 by 40 μm , i.e. at a timing when the punch 3 is moved downwardly (in a depthwise direction of the intermediate plate 8 and the workpiece plate 7) to a position corresponding to a depth which is equal to or greater than the thickness of the workpiece plate 7 (the thin plate made of a metal) and equal to or less than the thickness of the intermediate plate 8, and until before the punch 3 penetrates through the intermediate plate 8. In a test carried out under the above conditions, it was verified that the workpiece plate 7 is fully sheared. A sheared product portion of the workpiece plate can be easily extracted by

pushing or sucking it from thereabove or therebelow.

[0050] In the method designed to shear a thin plate made of a metal, through the intermediate plate 8, as in the third embodiment, it is preferable to stop the punch 3 before the punch 3 is moved by a distance equal to the thickness of the thin plate, as the earliest timing, or before the punch 3 penetrates the intermediate plate 8, as the latest timing, after the punch 3 is initially brought into contact with the upper surface of the intermediate plate 8. In other words, it is preferable that a thrust depth after the punch 3 is initially brought into contact with the upper surface of the intermediate plate 8, is set to a value equal to or greater than the thickness of the workpiece plate (thin plate made of a metal) and equal to or less than the thickness of the intermediate plate 8. A prerequisite in this case is that the thickness of the intermediate plate is greater than the thickness of the workpiece plate (thin plate made of a metal).

[FOURTH EMBODIMENT]

[0051] FIG. 4 illustrates a shearing method according to a fourth embodiment of the present invention. The fourth embodiment is one example where the present invention is applied to a shearing method using a die cut roll consisting of a die cutter and an anvil roll. A workpiece plate 1 in the fourth embodiment is the same as that in the first embodiment.

[0052] As shown in FIG. 4, a die cutter 4 has a convex push-cutting blade 4a provided on a surface thereof at a position corresponding to a shearing recess 5a of an anvil roll 5. The workpiece plate 1 is inserted between the die cutter 4 and the anvil roll 5 which are rotating in respective ones of the arrowed directions, and the convex push-cutting blade 4a of the die cutter is rotated and pressed toward the shearing recess 5a of the anvil roll 5 to shear the workpiece plate 1.

[0053] In the fourth embodiment, during the shearing operation, the workpiece plate 1 is sheared without causing the convex push-cutting blade 4a of the die cutter to penetrate through the workpiece plate 1 and become fitted into the shearing recess 5a of the anvil roll, as shown in FIG. 4. In the fourth embodiment, the convex push-cutting blade 4a is thrust to a position where a distal end thereof is located away from an upper surface of the workpiece plate 1 by 20 μm , i.e., a position corresponding to a depth equal to 11% of the thickness of the workpiece plate 1. In a test carried out under the above conditions, it was verified that the workpiece plate 1 is fully sheared in the same manner as that in the first embodiment. A sheared product portion of the workpiece plate can be easily extracted by pushing or sucking it from thereabove or therebelow.

[0054] Although not illustrated, another test was carried out under the following conditions: A workpiece plate stack formed by stacking two workpiece plates 1 on each other is inserted between the die cutter 4 and the anvil roll 5, and the convex push-cutting blade 4a is thrust to

a position corresponding to a depth equal to 36% of a thickness of the workpiece plate stack (two stacked workpiece plates 1). As a result, it was verified that all of the two workpiece plates 1 are fully sheared in the same manner as that in the second embodiment.

[0055] Although the fourth embodiment illustrated in FIG. 4 shows one example where the workpiece plate 1 is sheared which is prepared by laminating the two non-metal layers 1b on respective ones of the opposite surfaces of the metal layer 1a, it is also possible to shear a workpiece plate prepared by laminating one non-metal layer on one of opposite surfaces of a metal layer, in the same manner. Preferably, in this case, the workpiece plate is inserted to allow the non-metal layer to come into contact with the die cutter 4.

[0056] FIG. 5 illustrates one modification of the fourth embodiment in FIG. 4. In the modified embodiment illustrated in FIG. 5, an intermediate plate 6 having at least one non-metal layer is inserted between the die cutter 4 and the workpiece plate 1. Based on interposing the intermediate plate 6 in this manner, the workpiece plate 1 can be more reliably sheared by a pressing effect arising from plastic flow of the intermediate plate 6.

[0057] Specifically, as the intermediate plate 8, a non-metal layer may be used which is made of one selected from the group consisting of acrylic resin, PET, polycarbonate, bakelite, plastic, fluororesin, epoxy resin, polyurethane, polyvinyl chloride, polyamide, polyethylene, polypropylene, vinyl chloride, hard rubber, paper, glass plate, asphalt and synthetic fiber. Further, a laminated material comprised of two or more of the non-metal layers or a laminated material comprised of the non-metal layer and a metal layer may be used.

[FIFTH EMBODIMENT]

[0058] FIG. 6 illustrates a shearing method according to a fifth embodiment of the present invention. The fifth embodiment is one example where a thin plate made of a metal is sheared using a die cutter and an anvil roll.

[0059] As shown in FIG. 6, a die cutter 4 has a convex push-cutting blade 4a provided on a surface thereof at a position corresponding to a shearing recess 5a of an anvil roll 5. In the fifth embodiment, a thin plate made of a metal, as a workpiece plate 7, is inserted between the die cutter 4 and the anvil roll 5 which are rotating in respective ones of the arrowed directions, and an intermediate plate 6 having at least one non-metal layer is inserted between the die cutter 4 and the workpiece plate 7. Then, the convex push-cutting blade 4a of the die cutter is rotated so as to press the workpiece plate 7 toward the shearing recess 5a of the anvil roll 5 through the intermediate plate 6 to shear the workpiece plate 7. During the shearing operation, the workpiece plate 7 is sheared without causing the convex push-cutting blade 4a of the die cutter to penetrate through the intermediate plate 6 and the workpiece plate 7 and become fitted into the shearing recess 5a of the anvil roll.

[0060] In the method designed to shear the workpiece plate 7 (thin plate made of a metal) by the die cut roll through the intermediate plate 8, as in the fifth embodiment, it is preferable to set a distance (gap) between the die cutter 4 and the anvil roll 5, based on the same criteria as that in the third embodiment, in such a manner that a thrust depth of the workpiece plate (thin plate made of a metal) and the intermediate plate into the shearing recess 5a of the anvil roll becomes equal to or greater than a thickness of the workpiece plate and equal to or less than a thickness of the intermediate plate. In other words, it is preferable that the distance (gap) between the die cutter 4 and the anvil roll 5 is set to a value equal to or less than [(the thickness of the workpiece plate + the thickness of the intermediate plate) - the thickness of the workpiece plate] and equal to or greater than the thickness of the workpiece plate. A prerequisite in this case is that the thickness of the intermediate plate is greater than the thickness of the workpiece plate (thin plate made of a metal).

[0061] According to experimental tests carried out by the inventor, in the fourth and fifth embodiments using the die cutter 4 and the anvil roll 5, it is preferable that an outer peripheral shape of the convex push-cutting blade 4a of the die cutter is set to be equal to or slightly greater than an inner peripheral shape of the shearing recess 5a of the anvil roll. Specifically, as shown in FIG. 4, it is preferable to satisfy the following relationship: $B \leq A \leq 1.1 B$, where A is a length of one of four sides of the outer peripheral shape of the convex push-cutting blade 4a, and B is a length of a corresponding one of four sides of the inner peripheral shape of the shearing recess 5a. The reason is that, if A is less than B, burrs are likely to occur in a sheared portion, which causes deterioration in quality of a sheared surface. On the other hand; if A is greater than 1.1 B, a pressing portion, i.e., an area pressing the workpiece plate, becomes excessively widened, which causes deterioration in quality of the workpiece plate.

[0062] A shape of the convex push-cutting blade 4a of the die cutter for use in the present invention will be described below. In shearing using the die cutter, as shown in FIGS. 7(a) and 7(b), the convex push-cutting blade 4a of the die cutter is typically formed such that only an outer peripheral portion thereof protrudes outwardly to have an acute distal end. In the present invention, the convex push-cutting blade 4a is not necessarily formed in a protruding shape with an acute distal end as shown in FIGS. 7(a) and 7(b), because it is based on shearing. Thus, the convex push-cutting blade 4a may be formed to protrude in its entirety to have a right-angled edge as shown in FIGS. 7(c) and 7(d), or may be formed to protrude in its entirety to have an obtuse-angled edge as shown in FIGS. 7(e) and 7(f). Further, the edge may be rounded as indicated by the broken lines in FIGS. 7(d) and 7(f).

[SIXTH EMBODIMENT]

[0063] FIG. 8 illustrates a shearing method according to a sixth embodiment of the present invention. The sixth embodiment is one example where a workpiece plate is sheared using a press roll and an anvil roll. A workpiece plate 1 in the sixth embodiment is the same as that in the first embodiment.

[0064] As shown in FIG. 8, a press roll 9 has a smooth surface devoid of the convex push-cutting blade. An anvil roll 5 disposed opposed to the press roll 9 has a shearing recess 5a provided in a surface thereof in conformity to a shape of a product to be cut off. In the sixth embodiment, the workpiece plate 1 is inserted between the press roll 9 and the anvil roll 5 which are rotating in respective ones of the arrowed directions, and an intermediate plate 6 having at least one non-metal layer is inserted between the press roll 9 and the workpiece plate 1.

[0065] Then, the press roll 9 is rotated so as to press the workpiece plate 1 toward the shearing recess 5a of the anvil roll to shear the workpiece plate 1. During the shearing operation, the workpiece plate 1 is sheared without pressing the workpiece plate 1 into the shearing recess 5a of the anvil roll beyond a thickness of the workpiece plate 1. Specifically, the workpiece plate 1 is pressed to a position corresponding to a depth in the shearing recess 5a of the anvil roll which is equal to or greater than a thickness of a metal layer 1a and equal to or less than a total thickness of one or more non-metal layers 1b of the workpiece plate 1. In a test, the workpiece plate 1 was actually pressed into the shearing recess 5a of the anvil roll by a depth of 20 μm . As a result, it was verified that the workpiece plate 1 is fully sheared.

[0066] Although not illustrated, another test was carried out under the following conditions: A workpiece plate stack formed by stacking two workpiece plates 1 on each other is inserted between the press roll 9 and the anvil roll 5, and pressed into the shearing recess 5a of the anvil roll by a depth of 80 μm . As a result, it was verified that both of the two workpiece plates 1 are fully sheared.

[0067] FIG. 9 illustrates one modification of the sixth embodiment in FIG. 8. In the modified embodiment illustrated in FIG. 9, a thin plate made of a metal is sheared as a workpiece plate 7. Specifically, the press roll 9 is rotated so as to press the workpiece plate 7 into the shearing recess 5a of the anvil roll through an intermediate plate 6 to shear the workpiece plate 7.

[0068] More specifically, the workpiece plate is comprised of an aluminum foil having a thickness of 20 μm , and the intermediate plate 6 is comprised of a PET resin having a thickness of 500 μm . Further, a distance (gap) between the press roll 9 and the anvil roll 5 is set to 500 μm . In a test carried out under the above conditions, it was verified that the workpiece plate 7 is fully sheared.

[SEVENTH EMBODIMENT]

[0069] FIG. 10 illustrates a shearing method according

to a seventh embodiment of the present invention. In the embodiments illustrated in FIGS. 5, 6, 8 and 9, the intermediate plate 6 to be inserted between the workpiece plate 1 (7) and the die cutter 4 or press roll 9 is formed as a disposable type. Differently, an intermediate plate 6 in the seventh embodiment is formed as a repeatedly usable type.

[0070] Specifically, as shown in FIG. 10, the intermediate plate 6 is formed in an endless configuration. The intermediate plate 6 is inserted between a die cutter 4 and a workpiece plate 1 (7) so as to be used for shearing to and then passed between a pair of rolls 10, 10, whereafter the intermediate plate 6 is re-inserted between the die cutter 4 and the workpiece plate 1 (7). Thus, even if plastic deformation corresponding to a shearing recess 5a of the anvil roll (a convex push-cutting blade 4a of the die cutter) occurs in the intermediate plate 6 used for the shearing, due to the pressing during the shearing, the intermediate plate 6 is subsequently passed and pressed between the rolls 10, 10 and returned to a shape approximately identical to its original shape, so that it can be repeatedly used, which is also advantageous in terms of cost.

[0071] In cases where the intermediate plate is repeatedly used, it is preferable that a flexible material such as a rubber is used as a material for the intermediate plate 6 to allow the intermediate plate 6 to be easily returned to the original shape. Although the seventh embodiment in FIG. 10 shows one example using the die cutter 4, it is understood that a press roll may be used instead of the die cutter 4.

[EIGHTH EMBODIMENT]

[0072] FIG. 11 illustrates a shearing method according to an eighth embodiment of the present invention. The eighth embodiment is one example where a surface of a press roll 9 is coated with an outer layer 9a including at least one non-metal layer, instead of inserting an intermediate layer between the press roll 9 and a workpiece plate 1 (7).

[0073] The shearing method according to the eighth embodiment is capable of performing shearing in the same manner as that in the shearing method designed to insert the intermediate plate between the press roll 9 and the workpiece plate 1 (7), and avoiding using the intermediate plate in a throwaway manner. During shearing, the workpiece plate 1 (7) is sheared without pressing the workpiece plate 1 (7) into a shearing recess 5a of an anvil roll beyond a thickness of the workpiece plate 1(7). Preferably, the outer layer 9a is made of a flexible material such as a rubber to allow the outer layer 9a to be easily returned to its original shape.

[NINTH EMBODIMENT]

[0074] FIG. 12 illustrates a shearing method according to a ninth embodiment of the present invention. In the

ninth embodiment, at least two cutouts 5b are provided at respective positions before and after a shearing recess 5a of an anvil roll 5 in a rotation direction thereof, with a given distance from the shearing recess 5a.

[0075] Based on providing the cutout 5b in this manner, it becomes possible to prevent a workpiece plate 1 (7) from being pressed between a die cutter 4 and a portion of an anvil roll 5 unnecessary for shearing of a workpiece plate 1 (7). In other words, an outer peripheral portion of the anvil roll 5 having a length L between a shearing recess 5a of the anvil roll and each of the cutouts 5a is a region required for the shearing of the workpiece plate 1 (7). Thus, the cutouts 5b are provided while leaving the regions, so that it becomes possible to prevent the workpiece plate 1(7) from being pressed between the die cutter 4 and the portion of the anvil roll 5 unnecessary for the shearing, while allowing for the shearing of the workpiece plate 1(7). This makes it possible to prevent the workpiece plate 1 (7) from being damaged due to unnecessary pressing. Particularly, in a workpiece plate having an active material layer (non-metal layer) on a surface thereof as used in the first embodiment, the active material layer is brittle and damageable. Thus, the ninth embodiment is effective in such a workpiece plate.

[0076] Depending on a diameter of the anvil roll, it is desirable to set the length L in the range of 0.5 to 2 mm. If the length L is less than 0.5 mm, the anvil roll is likely to damage a surface region of the workpiece plate around a sheared surface. If the length L is greater than 2 mm, a pressing portion, i.e., an area pressing the workpiece plate, becomes excessively widened, which accelerates damage of the workpiece plate. Thus, it is most preferable to set the length L in the range of 0.5 to 2 mm, in view of preventing damage of a surface of the workpiece plate and minimizing the pressing portion. Although the ninth embodiment in FIG. 12 shows one example using the die cutter 4, it is understood that a press roll may be used instead of the die cutter 4.

[0077] In cases where an anvil roll is used in the above embodiments, it is preferable that a peripheral edge region of a shearing recess of the anvil roll is made of a material having hardness greater than that of the remaining region of the anvil roll. For example, the peripheral edge region of the shearing recess may be made of hard metal, ceramics or DCL coating. This makes it possible to prevent chipping or the like in the peripheral edge portion of the shearing recess which is a shearing area.

[0078] Further, preferably, each of the die cutter, the press roll and a body of the anvil roll is made of a material having a capability to facilitate ensuring machining accuracy, and a Young's modulus of 150 GPa or more.

EXPLANATION OF CODES

[0079]

1 : workpiece plate (thin plate including non-metal layer)

1a: metal layer
1b: non-metal layer
2: die
2a: shearing hole
3: punch
4: die cutter
4a: convex push-cutting blade
5: anvil roll
5a: shearing recess
5b: cutout
6: intermediate plate
7: workpiece plate (thin plate made of metal)
8: intermediate plate
9: press roll
9a: outer layer
10: roll

Claims

1. A method of shearing, comprising: placing between a punch (3) and a die (2) having a shearing hole (2a) either a thin plate (1) prepared by laminating one or more non-metal layers (16) on one or respective ones of opposite surfaces of a metal layer (1a) or a thin plate (7) made of a metal with an intermediate plate (8) having at least one non-metal layer, the intermediate plate (8) being placed between the thin plate (7) made of a metal and the punch (3); and relatively moving the punch (3) toward and with respect to the shearing hole (2a) to thereby shear the thin plate (1) or the thin plate (7) made of a metal, wherein the punch (3) is thrust into the thin plate (1) or the intermediate plate (8) and the relative movement of the punch (3) is stopped to complete the shearing, before the punch (3) penetrates through the thin plate (1) and becomes fitted into the shearing hole (2a) or before the punch (3) penetrates through the intermediate plate (8).
2. The method as defined in claim 1, wherein the metal layer (1b) of the thin plate (1a) has a thickness less than a total thickness of the one or more non-metal layers of the thin plate, and wherein the relative movement of the punch (3) is stopped at a position corresponding to a depth in the thin plate which is equal to or greater than the thickness of the metal layer and equal to or less than the total thickness of the one or more non-metal layers.
3. The method as defined in claim 1, wherein a plurality of the thin plates (1) are stacked on each other to form a thin plate stack and laced between the punch (3) and the die (2), and wherein the relative movement of the punch (3) is stopped to complete the shearing, before the punch penetrates through the thin plate stack and becomes fitted into the shearing hole.

4. The method as defined in claim 3, wherein the metal layer (1b) of the thin plate (1) has a thickness less than a total thickness of the one or more non-metal layers of the thin plate, and wherein the relative movement of the punch (3) is stopped at a position corresponding a depth in the thin plate stack which is equal to or greater than a total thickness of the metal layers of the thin plate stack and equal to or less than a total thickness of the non-metal layers of the thin plate stack.
5. The method as defined in an one of claims 1 to 4, wherein the thin plate (7) has a thickness less than that of the intermediate plate (8) and wherein the relative movement of the punch (3) is stopped at a position corresponding to a depth in a combination of the thin plate (7) and the intermediate plate (8) which is equal to or greater than the thickness of the thin plate and equal to or less than the thickness of the intermediate plate.
6. A method of shearing according to claim 1, wherein the punch is a convex push-cutting blade (4a) on a surface of a die cutter (4) and the die is an anvil roll (5) provided with a shearing recess (5a) as the shearing hole at a positions corresponding to the convex push-cutting blade; the convex push-cutting blade of the die cutter is rotated and pressed toward the shearing recess of the anvil roll to thereby shear the thin plate or the thin plate made of a metal, and the thin plate or the thin plate made of a metal is sheared without causing the convex push-cutting blade of the die cutter to penetrate through the thin plate and become fitted into the shearing recess of the anvil roll or penetrate through the intermediate plate and become fitted into the shearing recess of the anvil roll.
7. The method as defined in claim 6, wherein the metal layer (1a) of the thin plate (1) has a thickness less than a total thickness of the one or more non-metal layers (1b) of the thin plate, and wherein the convex push-cutting blade (4a) of the die cutter (4) is thrust to a position corresponding to a depth in the thin plate which is equal to or greater than the thickness of the metal layer and equal to or less than the total thickness of the one or more non-metal layers.
8. The method as defined in claim 6, wherein a plurality of the thin plates (1) are stacked on each other to form a thin plate stack and inserted between the die cutter (4) and the anvil roll (5), wherein all of the thin plates are sheared without causing the convex push-cutting blade of the die cutter to penetrate through the thin plate stack and become fitted into the shearing recess of the anvil roll.
9. The method as defined in claim 8, wherein the metal layer (1a) of the thin plate (1) has a thickness less than a total thickness of the one or more non-metal layers (1b) of the thin plate, and wherein the convex push-cutting blade of the die cutter is thrust to a position corresponding to a depth in the thin plate stack which is equal to or greater than a total thickness of the metal layers of the thin plate stack and equal to or less than a total thickness of the non-metal layers of the thin plate stack.
10. The method as defined in claim 6 or 8, wherein an intermediate plate (6) having at least one non-metal layer is inserted between the die cutter and the thin plate or thin plate stack.
11. The method as defined in claim 10, wherein the metal layer (1a) of the thin plate has a thickness less than a total thickness of the one or more non-metal layers (1b) of the thin plate and a thickness of the intermediate plate, and wherein the convex push-cutting blade of the die cutter is thrust to a position corresponding to a depth in a combination of the intermediate plate and the thin plate or thin plate stack which is equal to or greater than a total thickness of the metal layers of the thin plate or thin plate stack and equal to or less than a total thickness of the non-metal layers of the thin plate or thin plate stack and the intermediate plate.
12. The method as defined in claim 10 or 11, wherein the intermediate plate (6) is formed in an endless configuration, and wherein the intermediate plate is inserted between the die cutter and the thin plate or thin plate stack and then passed and pressed between a pair of rolls (4, 5), whereafter the intermediate plate (6) is re-inserted between the die cutter and the thin plate or thin plate stack.
13. The method as defined in any one of claims 6 to 12, wherein the shearing recess (5a) of the anvil roll (5) has a peripheral edge region made of a material having hardness greater than that of the remaining region of the anvil roll.
14. The method as defined in any one of claims 6 to 13, wherein the anvil roll (5) has at least two cutouts provided at respective positions before and after the shearing recess in a rotation direction thereof, with a given distance from the shearing recess.
15. The method as defined in claim 6, wherein the thin plate (7) has a thickness less than that of the intermediate plate (6), and wherein the convex push-cutting blade of the die cutter is thrust to a position corresponding to a depth in a combination of the thin plate and the intermediate plate which is equal to or greater than the thickness of the thin plate and equal to or less than the thickness of the intermediate plate.

16. The method as defined in claim 6 or 15, wherein the intermediate plate (6) is formed in an endless configuration, and wherein the intermediate plate (6) is inserted between the die cutter and the thin plate and then passed and pressed between the die cutter and the anvil roll, whereafter the intermediate plate is re-inserted between the die cutter and the thin plate.
17. The method as defined in any one of claims 6, 15 and 16, wherein the shearing recess (5a) of the anvil roll (5) has a peripheral edge region made of a material having hardness greater than that of the remaining region of the anvil roll.
18. The method as defined in any one of claims 6 and 15 to 17 wherein the anvil roll (5) has at least two cutouts provided at respective positions before and after the shearing recess in a rotation direction thereof, with a given distance from the shearing recess.

Patentansprüche

1. Scherverfahren, das aufweist: Anordnen zwischen einem Stanzstempel (3) und einer Matrize (2) mit einem Scherloch (2a) entweder einer dünnen Platte (1), die durch Schichten einer oder mehrerer Nichtmetallschichten (1b) auf eine oder jeweilige gegenüberliegende Oberflächen einer Metallschicht (1a) hergestellt wird, oder einer dünnen Platte (7), die aus einem Metall besteht, mit einer Zwischenplatte (8), die mindestens eine Nichtmetallschicht aufweist, wobei die Zwischenplatte (8) zwischen der dünnen Platte (7), die aus einem Metall besteht, und dem Stanzstempel (3) angeordnet wird; und relatives Bewegen des Stanzstempels (3) zum Scherloch (2a) und in Bezug darauf, um dadurch die dünne Platte (1) oder die dünne Platte (7), die aus einem Metall besteht, zu scheren, wobei der Stanzstempel (3) in die dünne Platte (1) oder die Zwischenplatte (8) eingetrieben wird, und die Relativbewegung des Stanzstempels (3) gestoppt wird, um das Scheren zu beenden, bevor der Stanzstempel (3) die dünne Platte (1) durchdringt und in das Scherloch (2a) eingepasst wird oder bevor der Stanzstempel (3) die Zwischenplatte (8) durchdringt.
2. Verfahren nach Anspruch 1, wobei die Metallschicht (1b) der dünnen Platte (1a) eine Dicke aufweist, die kleiner als eine Gesamtdicke der einen oder der mehreren Nichtmetallschichten der dünnen Platte ist, und wobei die Relativbewegung des Stanzstempels (3) an einer Position gestoppt wird, die einer Tiefe in der dünnen Platte entspricht, die gleich oder größer als die Dicke der Metallschicht und gleich oder kleiner als die Gesamtdicke der einen oder der mehreren Nichtmetallschichten ist.
3. Verfahren nach Anspruch 1, wobei mehrere der dünnen Platten (1) aufeinander gestapelt werden, um einen dünnen Plattenstapel zu bilden, und zwischen dem Stanzstempel (3) und der Matrize (2) angeordnet werden, und wobei die Relativbewegung des Stanzstempels (3) gestoppt wird, um das Scheren zu beenden, bevor der Stanzstempel den dünnen Plattenstapel durchdringt und in das Scherloch eingepasst wird.
4. Verfahren nach Anspruch 3, wobei die Metallschicht (1b) der dünnen Platte (1) eine Dicke aufweist, die kleiner als eine Gesamtdicke der einen oder der mehreren Nichtmetallschichten der dünnen Platte ist, und wobei die Relativbewegung des Stanzstempels (3) an einer Position gestoppt wird, die einer Tiefe im dünnen Plattenstapel entspricht, die gleich oder größer als eine Gesamtdicke der Metallschichten des dünnen Plattenstapels und gleich oder kleiner als eine Gesamtdicke der Nichtmetallschichten des dünnen Plattenstapels ist.
5. Verfahren nach einem der Ansprüche 1 bis 4, wobei die dünne Platte (7) eine Dicke aufweist, die kleiner als die der Zwischenplatte (8) ist, und wobei die Relativbewegung des Stanzstempels (3) an einer Position gestoppt wird, die einer Tiefe einer Kombination der dünnen Platte (7) und der Zwischenplatte (8) entspricht, die gleich oder größer als die Dicke der dünnen Platte und gleich oder kleiner als die Dicke der Zwischenplatte ist.
6. Scherverfahren nach Anspruch 1, wobei der Stanzstempel ein konvexes Druckschneidmesser (4a) auf einer Oberfläche einer Stanze (4) ist und die Matrize eine Ambosswalze (5) ist, die mit einer Scheraussparung (5a) als das Scherloch an einer Position versehen ist, die dem konvexen Druckschneidmesser entspricht; das konvexe Druckschneidmesser der Stanze gedreht und zur Scheraussparung der Ambosswalze gedrückt wird, um dadurch die dünne Platte oder die dünne Platte, die aus einem Metall besteht, zu scheren, und die dünne Platte oder die dünne Platte, die aus einem Metall besteht, geschert wird, ohne zu bewirken, dass das konvexe Druckschneidmesser der Stanze die dünne Platte durchdringt und in die Scheraussparung der Ambosswalze eingepasst wird oder die Zwischenplatte durchdringt und in die Scheraussparung der Ambosswalze eingepasst wird.
7. Verfahren nach Anspruch 6, wobei die Metallschicht (1a) der dünnen Platte (1) eine Dicke aufweist, die kleiner als eine Gesamtdicke der einen oder der mehreren Nichtmetallschichten (1b) der dünnen Platte ist, und wobei das konvexe Druckschneidmesser (4a) der Stanze (4) bis zu einer Position eingetrieben wird, die einer Tiefe in der dünnen Platte

entspricht, die gleich oder größer als die Dicke der Metallschicht und gleich oder kleiner als die Gesamtdicke der einen oder der mehreren Nichtmetallschichten ist.

8. Verfahren nach Anspruch 6, wobei mehrere der dünnen Platten (1) aufeinander gestapelt werden, um einen dünnen Plattenstapel zu bilden, und zwischen die Stanze (4) und die Ambosswalze (5) eingeführt werden, wobei alle dünnen Platten gesichert werden, ohne zu bewirken, dass das konvexe Druckschneidmesser der Stanze den dünnen Plattenstapel durchdringt und in die Scheraussparung der Ambosswalze eingepasst wird. 10
9. Verfahren nach Anspruch 8, wobei die Metallschicht (1a) der dünnen Platte (1) eine Dicke aufweist, die kleiner als eine Gesamtdicke der einen oder der mehreren Nichtmetallschichten (1b) der dünnen Platte ist, und wobei das konvexe Druckschneidmesser der Stanze bis zu einer Position eingetrieben wird, die einer Tiefe im dünnen Plattenstapel entspricht, die gleich oder größer als eine Gesamtdicke der Metallschichten des dünnen Plattenstapels und gleich oder kleiner als eine Gesamtdicke der Nichtmetallschichten des dünnen Plattenstapels ist. 20 25
10. Verfahren nach Anspruch 6 oder 8, wobei eine Zwischenplatte (6), die mindestens eine Nichtmetallschicht aufweist, zwischen die Stanze und die dünne Platte oder den dünnen Plattenstapel eingeführt wird. 30
11. Verfahren nach Anspruch 10, wobei die Metallschicht (1a) der dünnen Platte eine Dicke aufweist, die kleiner als eine Gesamtdicke der einen oder der mehreren Nichtmetallschichten (1b) der dünnen Platte und einer Dicke der Zwischenplatte ist, und wobei das konvexe Druckschneidmesser der Stanze bis zu einer Position eingetrieben wird, die einer Tiefe einer Kombination der Zwischenplatte und der dünnen Platte oder des dünnen Plattenstapels entspricht, die gleich oder größer als eine Gesamtdicke der Metallschichten der dünnen Platte oder des dünnen Plattenstapels und gleich oder kleiner als eine Gesamtdicke der Nichtmetallschichten der dünnen Platte oder des dünnen Plattenstapels und der Zwischenplatte ist. 35 40 45
12. Verfahren nach Anspruch 10 oder 11, wobei die Zwischenplatte (6) in einer endlosen Konfiguration ausgebildet ist, und wobei die Zwischenplatte zwischen die Stanze und die dünne Platte oder den dünnen Plattenstapel eingeführt wird und dann zwischen einem Walzenpaar (4, 5) hindurchgeleitet und gepresst wird, wonach die Zwischenplatte (6) erneut zwischen die Stanze und die dünnen Platte oder den dünnen Plattenstapel eingeführt wird. 50 55

13. Verfahren nach einem der Ansprüche 6 bis 12, wobei die Scheraussparung (5a) der Ambosswalze (5) einen Umfangskantenbereich aufweist, der aus einem Material besteht, das eine größere Härte als der restliche Bereich der Ambosswalze aufweist. 5

14. Verfahren nach einem der Ansprüche 6 bis 13, wobei die Ambosswalze (5) mindestens zwei Ausschnitte aufweist, die in deren Rotationsrichtung an jeweiligen Positionen vor und nach der Scheraussparung mit einem vorgegebenen Abstand von der Scheraussparung vorgesehen sind. 10

15. Verfahren nach Anspruch 6, wobei die dünne Platte (7) eine Dicke aufweist, die kleiner als die der Zwischenplatte (6) ist, und wobei das konvexe Druckschneidmesser der Stanze bis zu einer Position eingetrieben wird, die einer Tiefe einer Kombination der dünnen Platte und der Zwischenplatte entspricht, die gleich oder größer als die Dicke der dünnen Platte und gleich oder kleiner als die Dicke der Zwischenplatte ist. 15 20

16. Verfahren nach Anspruch 6 oder 15, wobei die Zwischenplatte (6) in einer endlosen Konfiguration ausgebildet ist, und wobei die Zwischenplatte (6) zwischen die Stanze und die dünne Platte eingeführt wird und dann zwischen der Stanze und der Ambosswalze hindurchgeführt und gepresst wird, wonach die Zwischenplatte erneut zwischen die Stanze und die dünne Platte eingeführt wird. 25 30

17. Verfahren nach einem der Ansprüche 6, 15 und 16, wobei die Scheraussparung (5a) der Ambosswalze (5) einen Umfangskantenbereich aufweist, der aus einem Material besteht, das eine größere Härte als der restliche Bereich der Ambosswalze aufweist. 35

18. Verfahren nach einem der Ansprüche 6 und 15 bis 17, wobei die Ambosswalze (5) mindestens zwei Ausschnitte aufweist, die in deren Rotationsrichtung an jeweiligen Positionen vor und nach der Scheraussparung mit einem vorgegebenen Abstand von der Scheraussparung vorgesehen sind. 40 45

Revendications

1. Procédé de cisaillement, comprenant les étapes suivantes : mise en place, entre un poinçon (3) et une matrice (2) pourvue d'un trou de cisaillement (2a), soit d'une plaque mince (1) préparée par stratification d'une ou de plusieurs couches non métalliques (1b) sur une face d'une couche métallique (1a) ou sur les faces opposées de celle-ci, soit d'une plaque mince (7) en métal avec une plaque intercalaire (8) comportant au moins une couche non métallique, la plaque intercalaire (8) étant disposée entre la pla-

- que mince (7) en métal et le poinçon (3) ; et déplacement relatif du poinçon (3) vers le trou de cisaillement (2a) et par rapport à celui-ci pour cisailier la plaque mince (1) ou la plaque mince (7) en métal, le poinçon (3) étant enfoncé dans la plaque mince (1) ou la plaque intercalaire (8), et le déplacement relatif du poinçon (3) étant arrêté pour compléter le cisaillement avant que le poinçon (3) traverse la plaque mince (1) et s'ajuste dans le trou de cisaillement (2a), ou avant que le poinçon (3) traverse la plaque intercalaire (8).
2. Procédé selon la revendication 1, où la couche métallique (1b) de la plaque mince (1a) présente une épaisseur inférieure à une épaisseur totale de la couche ou des couches non métalliques de la plaque mince, et où le déplacement relatif du poinçon (3) est arrêté sur une position correspondant à une profondeur dans la plaque mince, supérieure ou égale à l'épaisseur de la couche métallique et inférieure ou égale à l'épaisseur totale de la couche ou des couches non métalliques.
 3. Procédé selon la revendication 1, où plusieurs plaques minces (1) sont empilées pour former une pile de plaques minces et sont mises en place entre le poinçon (3) et la matrice (2), et où le déplacement relatif du poinçon (3) arrêté pour compléter le cisaillement avant que le poinçon traverse la pile de plaques minces et soit pris dans le trou de cisaillement.
 4. Procédé selon la revendication 3, où la couche métallique (1b) de la plaque mince (1) présente une épaisseur inférieure à une épaisseur totale de la couche ou des couches non métalliques de la plaque mince, et où le déplacement relatif du poinçon (3) est arrêté sur une position correspondant à une profondeur dans la pile de plaques minces, supérieure ou égale à une épaisseur totale des couches métalliques de la pile de plaques minces et inférieure ou égale à une épaisseur totale des couches non métalliques de la pile de plaques minces.
 5. Procédé selon l'une quelconque des revendications 1 à 4, où la plaque mince (7) présente une épaisseur inférieure à celle de la plaque intercalaire (8), et où le déplacement relatif du poinçon (3) est arrêté sur une position correspondant à une profondeur dans une combinaison de la plaque mince (7) et de la plaque intercalaire (8) qui est supérieure ou égale à l'épaisseur de la plaque mince et inférieure ou égale à l'épaisseur de la plaque intercalaire.
 6. Procédé de cisaillement selon la revendication 1, où le poinçon est une lame de découpe convexe (4a) sur une surface d'une poinçonneuse (4), et où la matrice est un rouleau-enclume (5) prévu avec un évidement de cisaillement (5a) en tant que trou de cisaillement à un emplacement correspondant à la lame de découpe convexe ; où la lame de découpe convexe de la poinçonneuse est entraînée en rotation et serrée contre l'évidement de cisaillement du rouleau-enclume pour cisailier la plaque mince ou la plaque mince en métal, et la plaque mince ou la plaque mince en métal sont cisailées sans que la lame de découpe convexe de la poinçonneuse traverse en conséquence la plaque mince et soit prise dans l'évidement de cisaillement du rouleau-enclume ou traverse la plaque intercalaire et soit prise dans l'évidement de cisaillement du rouleau-enclume.
 7. Procédé selon la revendication 6, où la couche métallique (1a) de la plaque mince (1) présente une épaisseur inférieure à une épaisseur totale de la couche ou des couches non métalliques (1b) de la plaque mince, et où la lame de découpe convexe (4a) de la poinçonneuse (4) est serrée vers une position correspondant à une profondeur dans la plaque mince qui est supérieure ou égale à l'épaisseur de la couche métallique et inférieure ou égale à l'épaisseur totale de la couche ou des couches non métalliques.
 8. Procédé selon la revendication 6, où plusieurs plaques minces (1) sont empilées pour former une pile de plaques minces et insérées entre la poinçonneuse (4) et le rouleau-enclume (5), où toutes les plaques minces sont cisailées sans que la lame de découpe convexe de la poinçonneuse traverse en conséquence la pile de plaques minces et soit prise dans l'évidement de cisaillement du rouleau-enclume.
 9. Procédé selon la revendication 8, où la couche métallique (1a) de la plaque mince (1) présente une épaisseur inférieure à une épaisseur totale de la couche ou des couches non métalliques (1b) de la plaque mince, et où la lame de découpe convexe de la poinçonneuse est serrée vers une position correspondant à une profondeur dans la pile de plaques minces qui est supérieure ou égale à une épaisseur totale des couches métalliques de la pile de plaques minces et inférieure ou égale à une épaisseur totale des couches non métalliques de la pile de plaques minces.
 10. Procédé selon la revendication 6 ou la revendication 8, où une plaque intercalaire (6) comportant au moins une couche non métallique est insérée entre la poinçonneuse et la plaque mince ou la pile de plaques minces.
 11. Procédé selon la revendication 10, où la couche métallique (1a) de la plaque mince présente une épaisseur inférieure à une épaisseur totale de la couche ou des couches non métalliques (1b) de la plaque mince et une épaisseur de la plaque intercalaire, et

où la lame de découpe convexe de la poinçonneuse est serrée vers une position correspondant à une profondeur dans une combinaison de la plaque intercalaire et de la plaque mince ou la pile de plaques minces qui est supérieure ou égale à l'épaisseur totale des couches métalliques de la plaque mince ou pile de plaques minces et inférieure ou égale à l'épaisseur totale des couches non métalliques de la plaque mince ou pile de plaques minces et de la plaque intercalaire.

12. Procédé selon la revendication 10 ou la revendication 11, où la plaque intercalaire (6) est formée suivant une configuration sans fin, et où la plaque intercalaire est insérée entre la poinçonneuse et la plaque mince ou la pile de plaques minces avant d'être introduite et serrée entre une paire de rouleaux (4, 5), ce après quoi la plaque intercalaire (6) est réinsérée entre la poinçonneuse et la plaque mince ou la pile de plaques minces.
13. Procédé selon l'une quelconque des revendications 6 à 12, où l'évidement de cisaillement (5a) du rouleau-enclume (5) présente une zone de bord périphérique en matériau de dureté supérieure à celle de la zone restante du rouleau-enclume.
14. Procédé selon l'une quelconque des revendications 6 à 13, où le rouleau-enclume (5) présente au moins deux échancrures prévues à des emplacements respectifs devant et derrière l'évidement de cisaillement dans le sens de rotation du rouleau-enclume, espacées d'une distance définie de l'évidement de cisaillement.
15. Procédé selon la revendication 6, où la plaque mince (7) présente une épaisseur inférieure à celle de la plaque intercalaire (6), et où la lame de découpe convexe de la poinçonneuse est serrée vers une position correspondant à une profondeur dans une combinaison de la plaque mince et de la plaque intercalaire qui est supérieure ou égale à l'épaisseur de la plaque mince et inférieure ou égale à l'épaisseur de la plaque intercalaire.
16. Procédé selon la revendication 6 ou 15, où la plaque intercalaire (6) est formée suivant une configuration sans fin, et où la plaque intercalaire (6) est insérée entre la poinçonneuse et la plaque mince avant d'être introduite et serrée entre la poinçonneuse et le rouleau-enclume, ce après quoi la plaque intercalaire est réinsérée entre la poinçonneuse et la plaque mince.
17. Procédé selon l'une quelconque des revendications 6, 15 et 16, où l'évidement de cisaillement (5a) du rouleau-enclume (5) présente une zone de bord périphérique en matériau de dureté supérieure à celle

de la zone restante du rouleau-enclume.

18. Procédé selon l'une quelconque des revendications 6 et 15 à 17, où le rouleau-enclume (5) présente au moins deux échancrures prévues à des emplacements respectifs devant et derrière l'évidement de cisaillement dans le sens de rotation du rouleau-enclume, espacées d'une distance définie de l'évidement de cisaillement.

Fig. 1

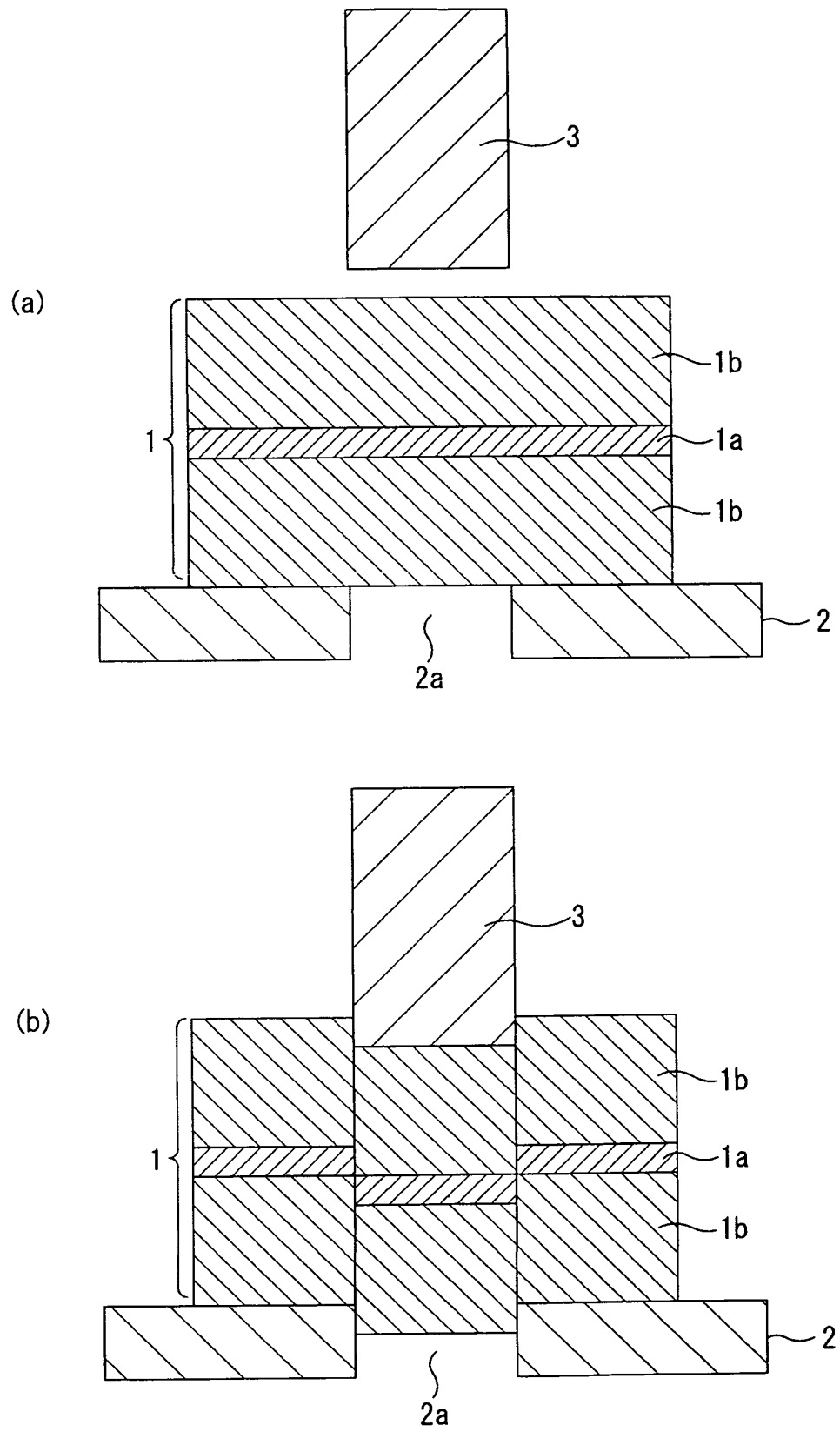


Fig. 2

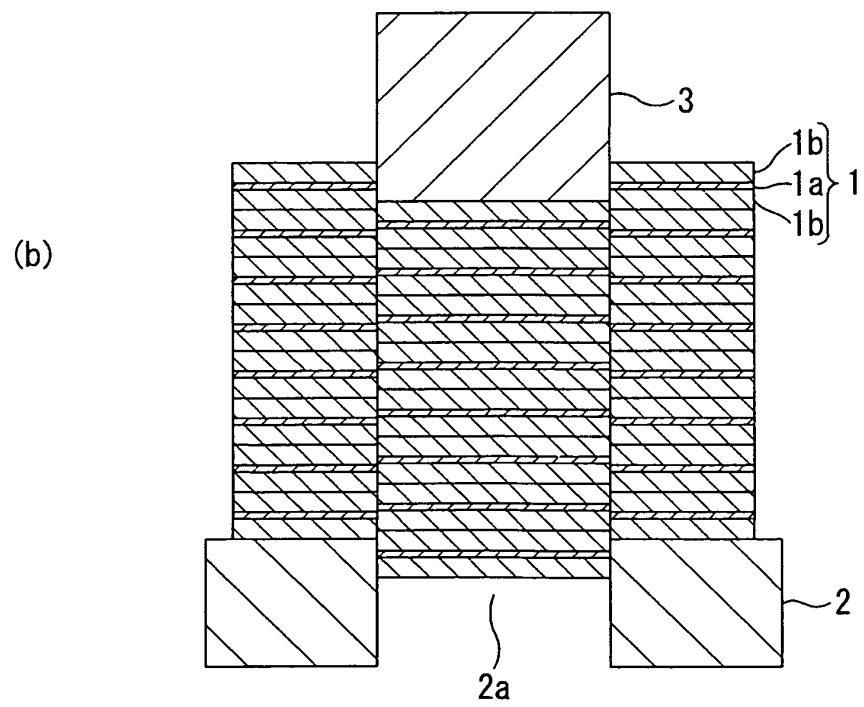
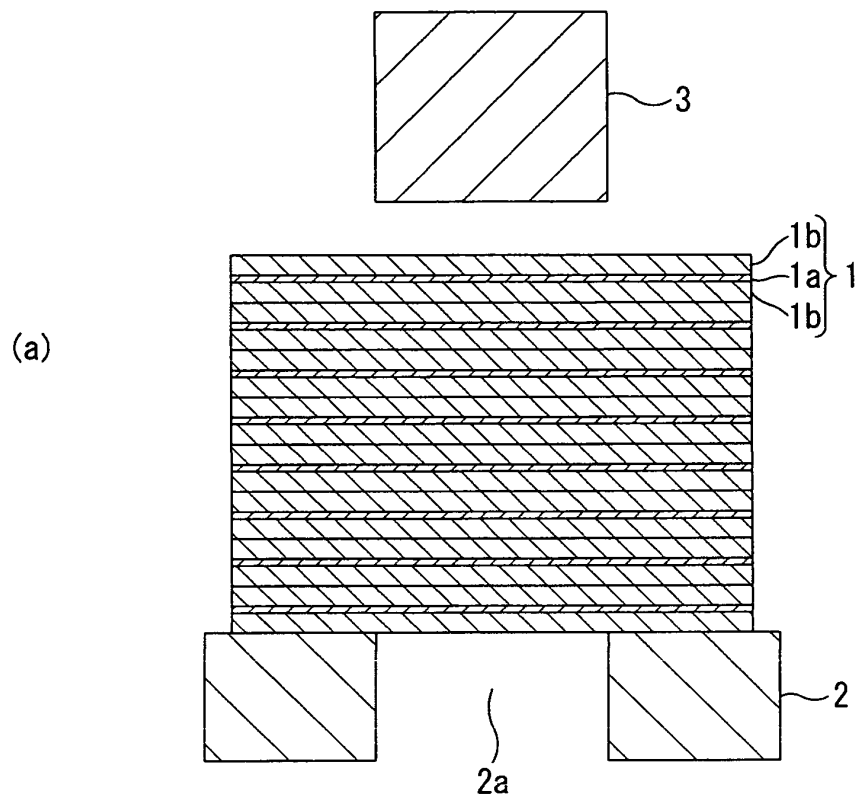


Fig. 3

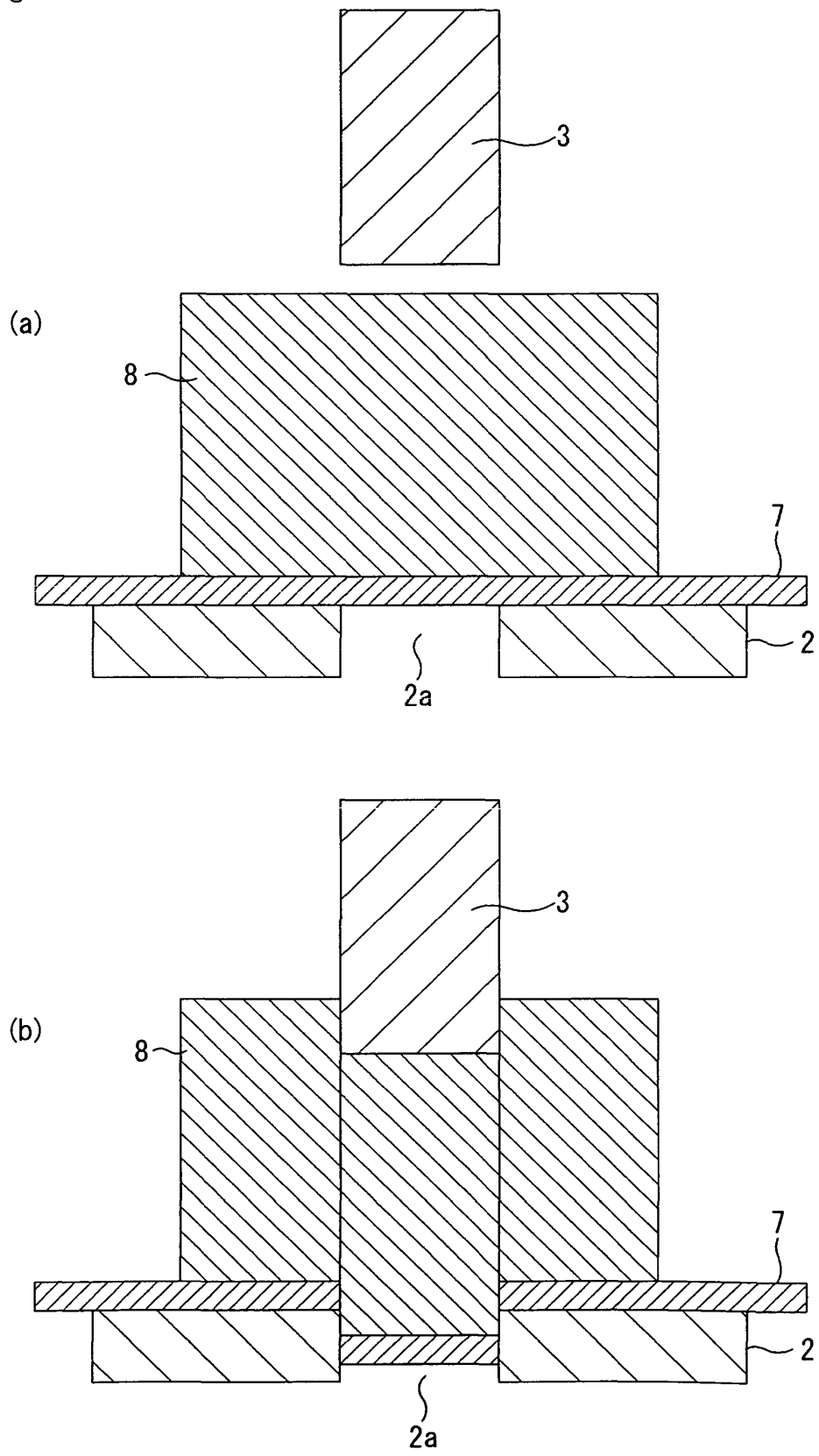


Fig. 4

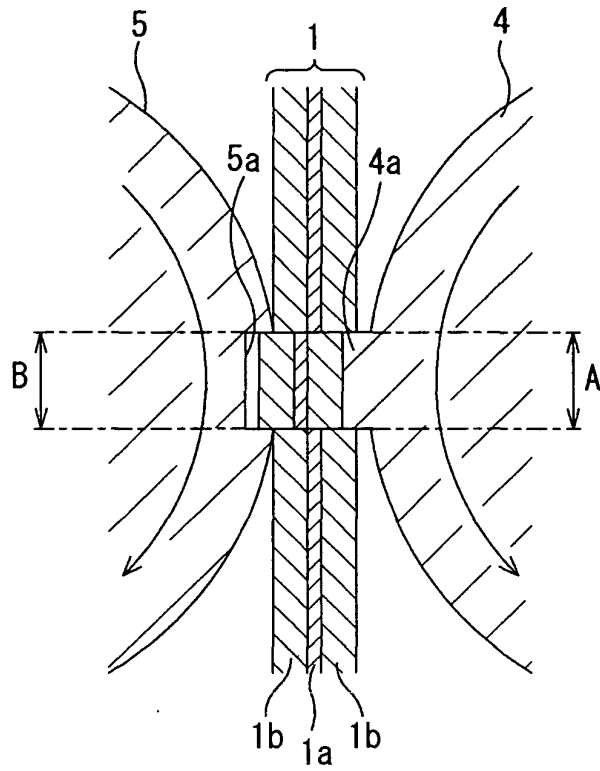


Fig. 5

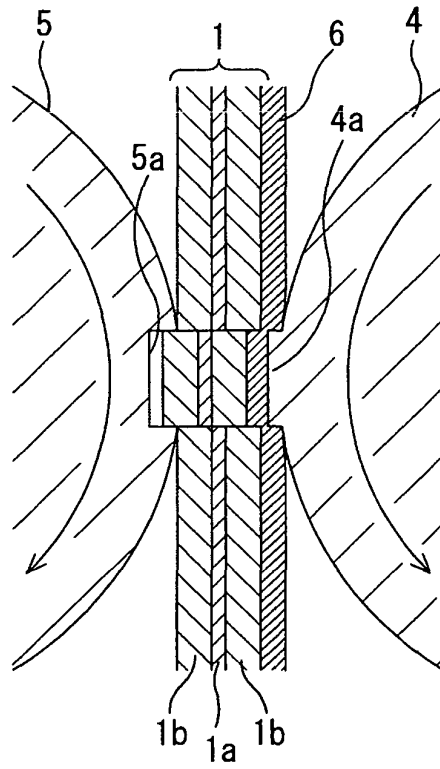


Fig. 6

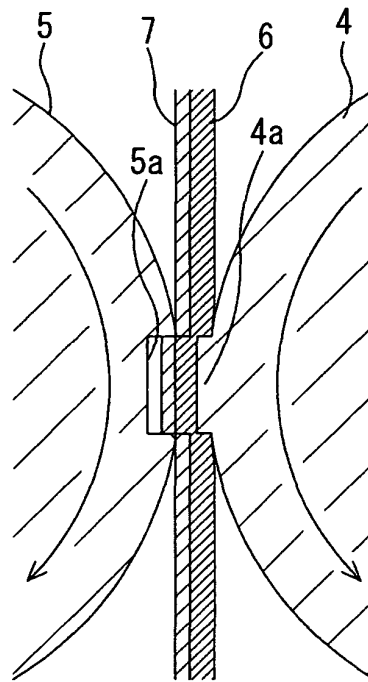


Fig. 8

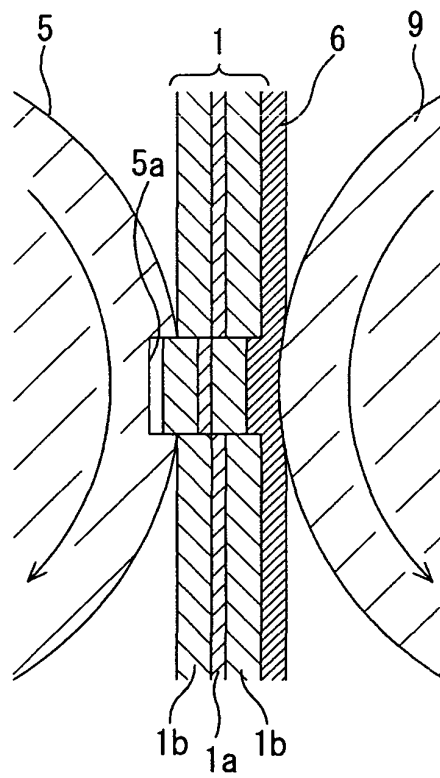


Fig. 7

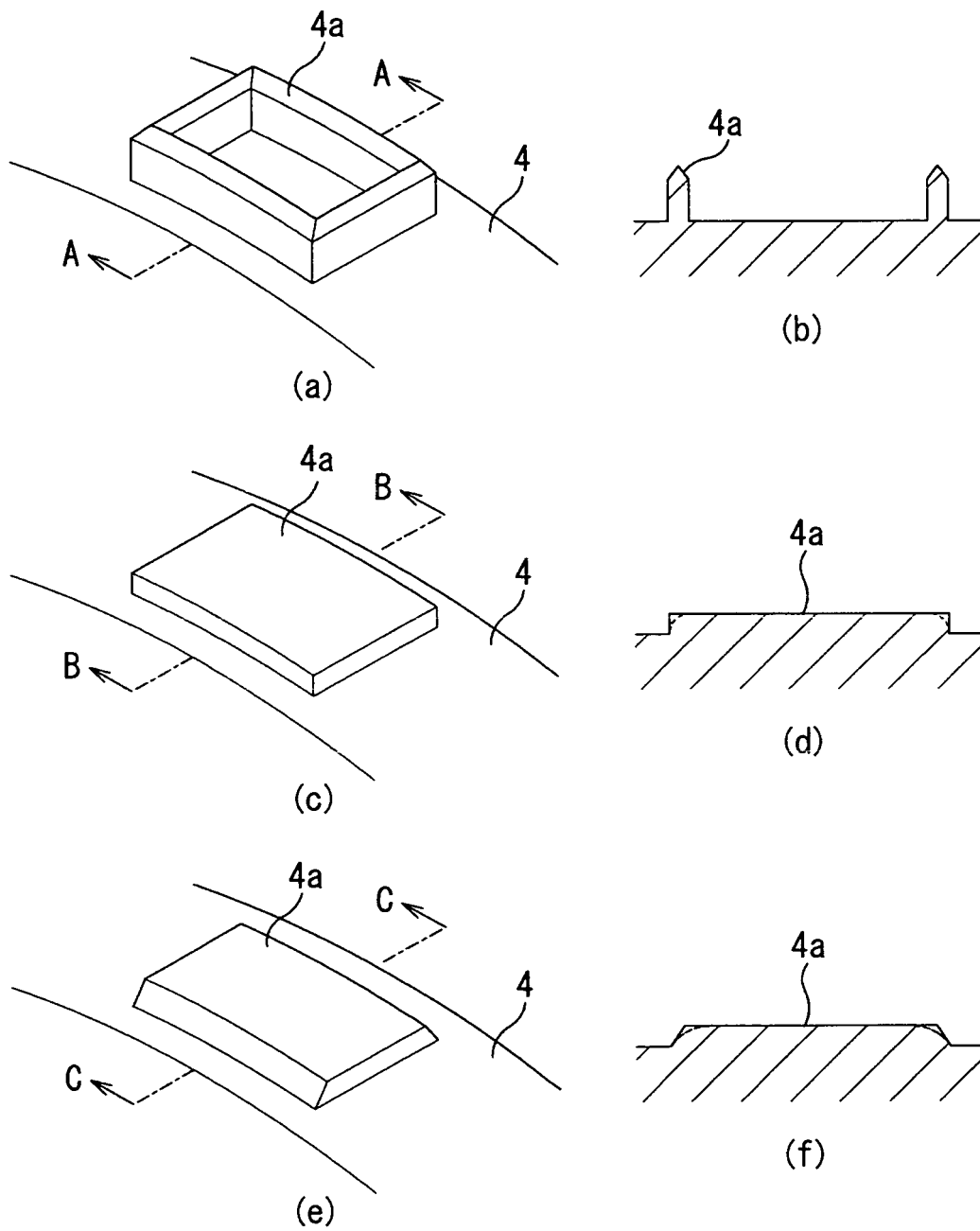


Fig. 9

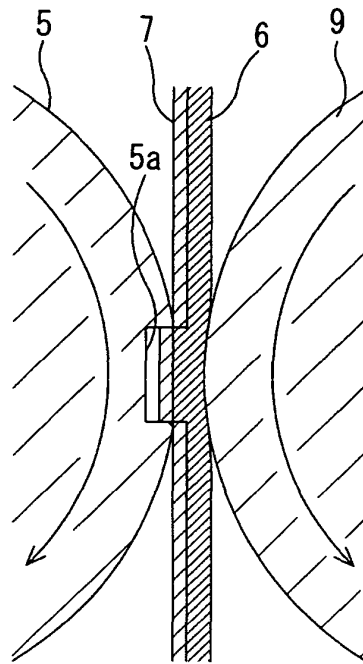


Fig. 10

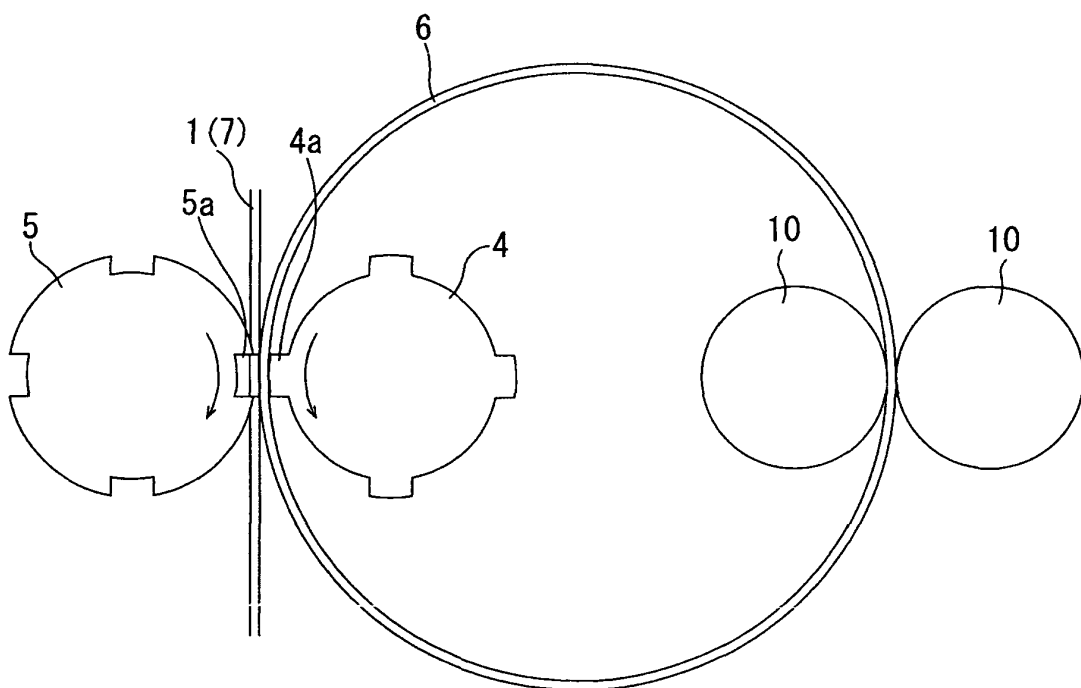


Fig. 11

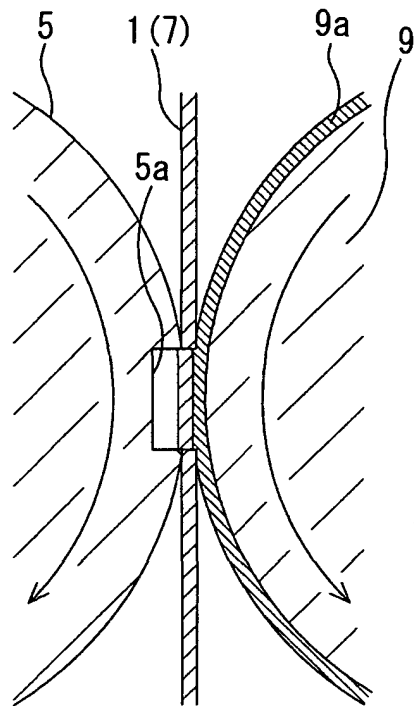
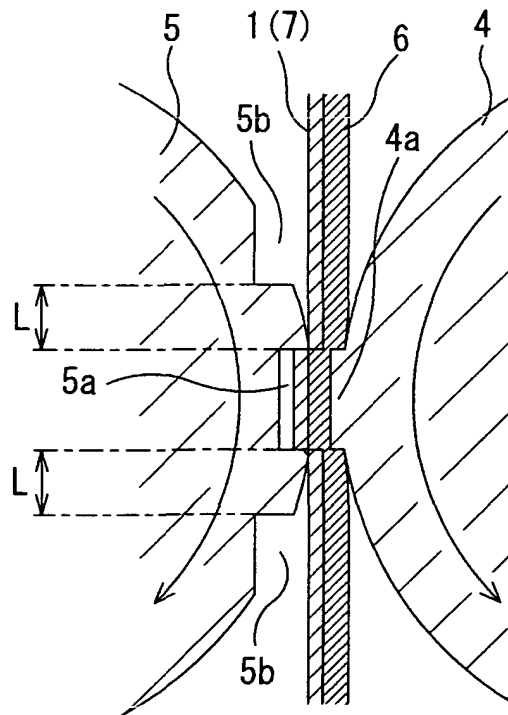


Fig. 12



REFERENCES CITED IN THE DESCRIPTION

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