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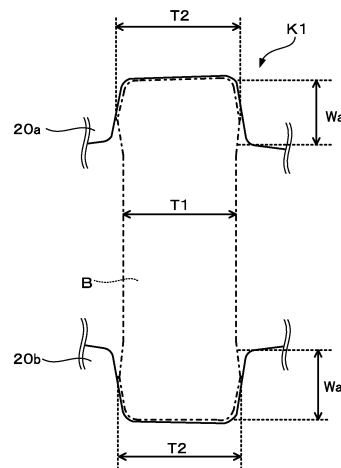
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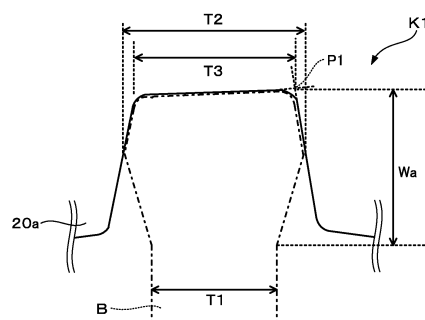
(54) **METHOD FOR MANUFACTURING HAT-SHAPED STEEL PILING**

(57) To suppress a material amount deficiency in arm parts which occurs at a rough shaping stage to produce a hat-shaped steel sheet pile product in a good shape when a large-size hat-shaped steel sheet pile is produced using a raw material in a rectangular cross-sectional shape (slab). A production method for producing a hat-shaped steel sheet pile by reducing a rectangular cross-sectional raw material, includes: edging rolling of performing reduction in a width direction on the rectangular cross-sectional raw material; and a first forming rolling of performing reduction in which a cross section of a material to be rolled after the edging rolling is formed into a substantially hat-shaped cross-sectional shape, wherein in the edging rolling, reduction in which a thickness of end parts in the width direction of the material to be rolled is increased using an edging caliber being a restraining caliber having a caliber bottom width T3 larger than a thickness T1 of the rectangular cross-sectional raw material to form into a dog-bone shape is performed.

FIG.12
(a)



(b)



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Description

[Technical Field]

(Cross-Reference to Related Applications)

[0001] This application is based upon and claims the benefit of priority of the prior Japanese Patent Application No. 2018-149325, filed in Japan on August 8, 2018, the entire contents of which are incorporated herein by reference.

[0002] The present invention relates to a production method for producing a hat-shaped steel sheet pile from a rectangular cross-sectional raw material.

[Background Art]

[0003] Conventionally, production of a steel sheet pile having joints at both ends of a hat shape, a U shape, or the like is performed by a caliber rolling method. Known as a general process of the caliber rolling method is first heating a raw material to a predetermined temperature in a heating furnace and sequentially rolling the raw material by a rough rolling mill, an intermediate rolling mill, and a finish rolling mill including calibers.

[0004] According to the above-described general caliber rolling method, a domestically produced steel sheet pile product can be produced from a raw material in a rectangular cross-section in status quo. Concretely, for example, a hat-shaped steel sheet pile product called a 10H product having a cross-section second moment per 1 m of a wall width of $1.0 (10^4 \text{ cm}^4/\text{m})$ and a hat-shaped steel sheet pile product called a 25H product having a cross-section second moment per 1 m of a wall width of $2.5 (10^4 \text{ cm}^4/\text{m})$ are produced by the conventionally known general caliber rolling method.

[0005] As a technique of producing a steel sheet pile from a rectangular cross-sectional raw material or a raw material similar thereto, various technologies have been conceived. For example, Patent Document 1 discloses a technique of using a beam blank material for H-shaped steel to produce a U-shaped steel sheet pile. Further, for example, Patent Document 2 discloses a technique of using a rectangular slab as a raw material to form the raw material into a suitable shape (predetermined width and thickness) with a box caliber, thereby stabilizing biting at a subsequent process. Besides, for example, Patent Document 3 discloses a technique of increasing caliber restraining force by using a rectangular slab as a raw material and using a deformed box caliber on the raw material to prevent biting-out, improve a centering property, and the like.

[0006] Besides, for example, Patent Document 4 discloses a technique of performing such width reduction as forms a local bulge on a slab surface in order to form a protruding ridge on a joint of a steel sheet pile in producing a steel sheet pile having a large effective width. Further, for example, Patent Document 5 discloses a

technique of suppressing a shape defect at an end part of a material to be rolled in production of a steel sheet pile.

[Prior Art Document]

[Patent Document]

[0007]

[Patent Document 1] Japanese Laid-open Patent Publication No. H10-192905

[Patent Document 2] Japanese Laid-open Patent Publication No. H09-182901

[Patent Document 3] Japanese Laid-open Patent Publication No. H10-113707

[Patent Document 4] Japanese Laid-open Patent Publication No. 2005-144497

[Patent Document 5] International Publication Pamphlet No. WO 2018/139521 A1

[Disclosure of the Invention]

[Problems to Be Solved by the Invention]

[0008] In recent years, accompanying an increase in size of building structures or use for offshore structures, production of a hat-shaped steel sheet pile product with a size larger as compared with conventional ones is required, and in particular, a product having the full width and height larger as compared with those of the conventional ones is desired. According to studies of the present inventors, it has been found that there are various problems when such a large-size hat-shaped steel sheet pile is produced from a rectangular cross-sectional raw material (hereinafter, also called a slab).

[0009] For example, when the large-size hat-shaped steel sheet pile is produced, the rectangular cross-sectional raw material is also required to increase its size, and when such a large-size rectangular cross-sectional raw material is formed, the increase in size of the raw material causes a problem such as a material amount deficiency in a part of a cross section of the material to be rolled, resulting in that there is a possibility of failing to produce a product in a desired shape. Concretely, an amount of deformation at a time of bending deformation increases, or a bending moment arm being a starting point of the bending deformation extends to make the bending deformation superior to shear deformation, and thus there is the possibility of causing the material amount deficiency (metal deficiency) in a part of the cross section of the material to be rolled. In particular, metal in end surface parts of the rectangular cross-sectional raw material is drawn into a middle part thereof, resulting in that there is a possibility that metal in portions being arm parts of the hat-shaped steel sheet pile later is deficient.

[0010] Note that the "large-size hat-shaped steel sheet pile" in this description means, for example, a steel sheet pile product having dimensions exceeding product di-

mensions of 900 mm in effective width and 300 mm in effective height (so-called 25H product).

[0011] Regarding such problems, because the technique described in the above Patent Document 1 targets the U-shaped steel sheet pile having no arm part, and adopts a configuration to deform portions in each of which a thickness is increased in a dog-bone shape into flange parts, there is no reference to the metal deficiency in the portions being the arm parts. Besides, the technique described in the above Patent Document 1, to begin with, does not adopt a technical idea such that a steel sheet pile is produced using a raw material in a rectangular cross-sectional shape (slab), and thus there is no room for occurrence of the problem such as the material amount deficiency in the end surface parts of the rectangular cross-sectional raw material as described above.

[0012] Besides, because the technique described in the above Patent Document 2 is a technique according to production of a U-shaped steel sheet pile having no arm part despite performing such shaping as to match a material to be rolled with a shape of an upper roll to stabilize the biting in a caliber, there is no reference to the problem such as the material amount deficiency in the end surface parts of the rectangular cross-sectional raw material as described above at a time of the biting, and the problem is not even suggested.

[0013] Besides, the technique described in the above Patent Document 3 points at an improvement in rolling stability such as the improvement in the centering property by increasing restraining force with caliber contact in the box caliber being surface contact. However, also in the above Patent Document 3, there is no reference to the problem such as the material amount deficiency in the end surface parts of the rectangular cross-sectional raw material.

[0014] Besides, the technique described in the above Patent Document 4 discloses the effect of performing such width reduction as forms the local bulge on the slab surface in order to form the protruding ridge on the joint of the steel sheet pile in producing the steel sheet pile having a large effective width. However, the technique of the above Patent Document 4 aims at forming the protruding ridge, and there is no reference to the problem such as the material amount deficiency in the end surface parts of the rectangular cross-sectional raw material as described above, and the problem is not even suggested.

[0015] Further, the technique described in the above Patent Document 5 discloses a technique of suppressing the shape defect of a bite end part at a rough rolling step in production of the steel sheet pile to improve productivity. Patent Document 5 refers to bulging deformation of a slab in edging rolling, and gives an explanation that the bulging deformation is a factor that facilitates the shape defect at the bite end part, and naturally, there is no reference to the problem regarding the material amount deficiency in the end surface parts of the rectangular cross-sectional raw material and means for solving the problem.

[0016] In view of the above circumstance, an object of the present invention is to provide a technique which makes it possible to suppress a material amount deficiency in arm parts which occurs at a rough shaping stage to produce a hat-shaped steel sheet pile product in a good shape when a large-size hat-shaped steel sheet pile is produced using a raw material in a rectangular cross-sectional shape (slab).

10 [Means for Solving the Problems]

[0017] To achieve the above object, according to the present invention, there is provided a production method for producing a hat-shaped steel sheet pile by reducing a rectangular cross-sectional raw material, the production method including: edging rolling of performing reduction in a width direction on the rectangular cross-sectional raw material; and a first forming rolling of performing reduction in which a cross section of a material to be rolled after the edging rolling is formed into a substantially hat-shaped cross-sectional shape, wherein in the edging rolling, reduction in which a thickness of end parts in the width direction of the material to be rolled is increased using an edging caliber being a restraining caliber having a caliber bottom width T3 larger than a thickness T1 of the rectangular cross-sectional raw material to form into a dog-bone shape is performed.

[0018] In the edging rolling, a range Wa in which a thickness is increased in the width direction of the rectangular cross-sectional raw material may be set as a range corresponding to a part or a whole of a width Wb of a portion corresponding to an arm of the material to be rolled in the first forming rolling.

[0019] In the edging rolling, the range Wa in which a thickness is increased in the width direction of the rectangular cross-sectional raw material may be defined by a portion having a thickness larger than the caliber bottom width T3 of the edging caliber, and a relation between the range Wa in which a thickness is increased in the width direction of the rectangular cross-sectional raw material and the width Wb of the portion corresponding to the arm of the material to be rolled in the first forming rolling may satisfy $Wa \leq Wb$.

45 [Effect of the Invention]

[0020] According to the present invention, it is possible to suppress a material amount deficiency in arm parts which occurs at a rough shaping stage to produce a hat-shaped steel sheet pile product in a good shape when a large-size hat-shaped steel sheet pile is produced using a raw material in a rectangular cross-sectional shape (slab).

55 [Brief Description of the Drawings]

[0021]

[FIG. 1] A schematic explanatory view of a rolling line according to an embodiment of the present invention.

[FIG. 2] A schematic explanatory view of the caliber shape of a first caliber.

[FIG. 3] A schematic explanatory view of the caliber shape of a second caliber.

[FIG. 4] A schematic explanatory view of the caliber shape of a third caliber.

[FIG. 5] A schematic explanatory view of the caliber shape of a fourth caliber.

[FIG. 6] A schematic explanatory view of the caliber shape of a fifth caliber.

[FIG. 7] A schematic explanatory view of the caliber shape of a sixth caliber.

[FIG. 8] A schematic explanatory view illustrating a depressed height H with respect to a raw material and a bending deformation moment arm L in the second caliber (first forming caliber).

[FIGs. 9] Schematic explanatory views illustrating conditions of reduction of the raw material in the second caliber (first forming caliber).

[FIGs. 10] Partially enlarged views of FIGs. 9.

[FIGs. 11] A chart obtained by converting changes of a full width of upper surface t1 and a full width maximum t2 of the raw material into numerals by FEM analysis when rolling and shaping of the raw material in the second caliber (first forming caliber) is performed in a plurality of passes.

[FIGs. 12] Schematic views when edging rolling is performed on the raw material to increase a thickness of end parts in a width direction.

[FIGs. 13] Schematic explanatory views comparing a cross section in the rolling and shaping in the second caliber (first forming caliber) when the thickness of the end part in the width direction of the raw material in the edging rolling according to the present invention is increased, and, a cross section in the rolling and shaping in the second caliber (first forming caliber) when the raw material has a conventional rectangular cross-section as it is.

[FIG. 14] A schematic view comparing cross-sectional shapes of materials to be rolled at a time of completion of the rolling and shaping in the second caliber (first forming caliber).

[FIG. 15] A chart obtained by converting changes of full widths of upper surfaces t1 and full width maximums t2 of raw materials into numerals by FEM analysis when the rolling and shaping of the raw materials in the second caliber K2 (first forming caliber) is performed in a plurality of passes after the edging rolling is performed on slabs each having a width larger than a width of the second caliber (first forming caliber) to increase a thickness of end parts in a width direction of the raw material.

[FIG. 16] An explanatory view regarding biting-out.

[Embodiments for Carrying out the Invention]

[0022] Hereinafter, an embodiment of the present invention will be explained referring to the drawings. Note that, in this description and the drawings, the same codes are given to components having substantially the same functional configurations to omit duplicated explanation. Note that the explanation will be made illustrating a case of rolling and shaping a hat-shaped steel sheet pile in an upward open state (so-called U-shaped posture) regarding production of a steel sheet pile product in this embodiment.

[0023] Besides, in this embodiment, a material having a rectangular cross-section (so-called slab) is called a raw material B and a material to be rolled made by reducing the raw material B into a substantially hat-shaped cross-sectional shape is called a material to be rolled A for convenience of explanation. More specifically, steel materials in the substantially hat-shaped cross-sectional shape to be passed on a rolling line S are generically called a material to be rolled A, and portions of the material to be rolled A are described by different names mentioned below. Here, in this description, in the raw material B in the rectangular cross-section, a long side direction of the rectangular cross-section is set as a width direction, and a short side direction thereof is set as a thickness direction. Besides, the material to be rolled A is composed of a web corresponding part 3 corresponding to a web of a hat-shaped steel sheet pile product, flange corresponding parts 4, 5 connected to both end parts of the web corresponding part 3 respectively, arm corresponding parts 6, 7 formed at tip ends of the flange corresponding parts 4, 5 respectively, and joint corresponding parts 8, 9 formed at tip ends of the arm corresponding parts 6, 7.

(Outline of production line)

[0024] FIG. 1 is an explanatory view of the rolling line S for producing the hat-shaped steel sheet pile being a rolling facility according to the embodiment of the present invention, and rolling mills provided on the rolling line S. As illustrated in FIG. 1, on the rolling line S, a rough rolling mill (BD) 11, an intermediate rolling mill (R) 12, and a finish rolling mill (F) 14 are arranged in order. The rolling line S is composed of a plurality of lines S1 to S3, in which the line S1 and the line S2 are adjacent to each other and the line S2 and the line S3 are adjacent to each other. The lines S1 to S3 are coupled in series to partially overlap each other, and configured such that the material to be rolled A is translated from S1 to S2 or S2 to S3 in a width direction thereof to thereby proceed on the rolling line S.

[0025] Further, as illustrated in FIG. 1, the rough rolling mill 11 is arranged on the line S1, the intermediate rolling mill 12 is arranged on the line S2, and the finish rolling mill 14 is arranged on the third line S3. The lines S1 to S3 are configured to be capable of performing rolling with different materials to be rolled A placed thereon respec-

tively, and to be capable of performing rolling of a plurality of materials to be rolled A simultaneously in parallel on the rolling line S.

[0026] On the rolling line S illustrated in FIG. 1, a raw material having a rectangular cross-sectional shape (the raw material B, the later material to be rolled A) heated in a not-illustrated heating furnace is sequentially rolled in the rough rolling mill 11 to the finish rolling mill 14 to form into a hat-shaped steel sheet pile being a final product. In other words, a rough rolling step, an intermediate rolling step, and a finish rolling step are performed in this order on the raw material B (the material to be rolled A) to thereby produce a final product.

(Outline of each caliber configuration)

[0027] Hereinafter, configurations of calibers engraved in the rough rolling mill 11, the intermediate rolling mill 12, and the finish rolling mill 14 arranged on the rolling line S (hereinafter, a plurality of rolling mills are also sometimes described in an abbreviation manner such as the rough rolling mill 11 to the finish rolling mill 14) will be briefly explained referring to the drawings in order from the upstream of the rolling line S. Note that since the above-described rough rolling mill 11, intermediate rolling mill 12, and finish rolling mill 14 are conventionally generally used facilities excluding detailed shapes and configurations of the calibers, attention is focused on explanation of the configurations of the calibers but explanation of the detailed facility configurations and so on of the rolling mills is omitted in the following explanation in this description.

[0028] Further, calibers explained below referring to FIG. 2 to FIG. 7 are engraved in the rolling mills of the rough rolling mill 11 to the finish rolling mill 14, and which rolling mill each of the calibers explained below is engraved in can be appropriately changed usually depending on the conditions such as a facility status, product dimensions, and so on in consideration of the productivity (efficiency and yields) and workability. Hence, the calibers are called a first caliber K1 to a sixth caliber K6 in this embodiment, and the calibers will be explained as those which may be engraved in order from the upstream side of the rolling line S. Note that the shapes of the raw material B and the material to be rolled A which are to be reduced and shaped in the calibers are illustrated by a one-dotted chain line for reference in FIG. 3 to FIG. 9.

[0029] However, the configurations of the first caliber K1 to the sixth caliber K6 according to this embodiment explained below are not limited to the illustrated forms, but, for example, the increased/decreased arrangement of correction calibers for various calibers can be appropriately changed according to the conditions such as a facility status, product dimensions, and so on. Note that in the first caliber K1 to the sixth caliber K6 explained below, rolling and shaping of the material to be rolled is desired to be the shaping in one pass for each of the calibers, but, particularly at the rough rolling step, due to

constraint of a biting property and a load characteristic, may be performed in reverse rolling (reversing rolling) in a plurality of passes, and the number of passes can be arbitrarily set according to characteristics of the rolling mills, or the like.

[0030] FIG. 2 is a schematic explanatory view of the caliber shape of the first caliber K1. As illustrated in FIG. 2, the first caliber K1 is a box caliber composed of an upper caliber roll 20a and a lower caliber roll 20b, and caliber bottoms of the box caliber are in predetermined tapered shapes. The first caliber K1 imparts the tapered shapes to short side parts at end parts in the width direction of the raw material B in a rectangular cross-sectional shape and performs light reduction (so-called edging rolling) in the width direction in a state where the not-illustrated raw material B in a rectangular cross-sectional shape is made to stand up (a state of setting the width direction of a steel sheet pile in the vertical direction) in order to make a uniform width dimension in the longitudinal direction. The light reduction here is performed at a reduction amount of the degree to which dimension variations of the raw material B during casting, or the like are corrected. Note that the reason why the tapered shapes are imparted to the end parts in the width direction of the raw material B in a rectangular cross-sectional shape is to cause the raw material B to preferably bites into the caliber shape of the later-described second caliber K2, and to stably perform desired reduction. In other words, the "tapered shape" here means such a shape of a caliber bottom surface as can impart a gentle-slop shape to the end parts in the width direction of the not-illustrated raw material B through the light reduction. The first caliber K1 illustrated in FIG. 2 is a caliber that performs so-called edging rolling, and the first caliber K1 is called an "edging caliber".

[0031] Besides, FIG. 3 is a schematic explanatory view of the caliber shape of the second caliber K2. As illustrated in FIG. 3, the second caliber K2 is composed of an upper caliber roll 30a as a projection roll and a lower caliber roll 30b as a groove roll. The second caliber K2 performs reduction on the whole raw material B (the later material to be rolled A) in a rectangular cross-sectional shape subjected to the edging rolling in the above first caliber K1. Here, the raw material B is in a state of being made to stand up in the reduction in the above first caliber K1, and the raw material B is thereafter rotated 90° or 270° and subjected to reduction in the second caliber K2 in a state where the width direction of the raw material B is set in the horizontal direction (a state of setting the width direction of the steel sheet pile in the horizontal direction), whereby rolling and shaping is performed to form a cross section from the rectangular cross-sectional shape into the substantially hat-shaped cross-sectional shape. Note that in this description, the second caliber K2 is also called a "first forming caliber" which performs a first forming rolling. The substantially hat-shaped cross-sectional shape here means a cross-sectional shape made by performing reduction to such a degree that the

raw material B has clear boundaries of a portion corresponding to a web (web corresponding part 3), portions corresponding to flanges (flange corresponding parts 4, 5), and portions corresponding to arms (arm corresponding parts 6, 7), and does not always mean the cross-sectional shape shaped up to fine shapes such as joint shapes and so on.

[0032] The upper caliber roll 30a is composed of a web facing part 32 facing the upper surface of the web corresponding part 3 of the raw material B, flange facing parts 34, 35 facing the upper surfaces of the flange corresponding parts 4, 5, and arm facing parts 37, 38 facing the upper surfaces of the arm corresponding parts 6, 7.

[0033] On the other hand, the lower caliber roll 30b is composed of a web facing part 42 facing the lower surface of the web corresponding part 3 of the raw material B, flange facing parts 44, 45 facing the lower surfaces of the flange corresponding parts 4, 5, and arm facing parts 47, 48 facing the lower surfaces of the arm corresponding parts 6, 7.

[0034] Further, FIG. 4 is a schematic explanatory view of the caliber shape of the third caliber K3. As illustrated in FIG. 4, the third caliber K3 is composed of an upper caliber roll 50a as a projection roll and a lower caliber roll 50b as a groove roll. The third caliber K3 performs further reduction on the material to be rolled A subjected to the shaping in the second caliber K2 to roughly form the joint shapes together, and performs, on the whole material to be rolled A, reduction to form the cross-sectional shape from the substantially hat-shaped cross-section shape into the substantially hat-shaped cross-sectional shape formed with joint parts. In this description, the third caliber K3 is also called a "second forming caliber" which performs a second forming rolling.

[0035] The upper caliber roll 50a is composed of a web facing part 52 facing the upper surface of the web corresponding part 3 of the material to be rolled A, flange facing parts 54, 55 facing the upper surfaces of the flange corresponding parts 4, 5, and arm facing parts 57, 58 facing the upper surfaces of the arm corresponding parts 6, 7.

[0036] Further, the lower caliber roll 50b is composed of a web facing part 62 facing the lower surface of the web corresponding part 3 of the material to be rolled A, flange facing parts 64, 65 facing the lower surfaces of the flange corresponding parts 4, 5, and arm facing parts 67, 68 facing the lower surfaces of the arm corresponding parts 6, 7.

[0037] FIG. 5 is a schematic explanatory view of the caliber shape of the fourth caliber K4. As illustrated in FIG. 5, the fourth caliber K4 is composed of an upper caliber roll 70a as a projection roll and a lower caliber roll 70b as a groove roll. The fourth caliber K4 performs further forming of the joint shapes and performs thickness reduction and forming (thickness drawing rolling) on the whole material to be rolled A, which is formed into a shape closer to the hat-shaped steel sheet pile product.

[0038] FIG. 6 is a schematic explanatory view of the caliber shape of the fifth caliber K5. As illustrated in FIG.

6, the fifth caliber K5 is composed of an upper caliber roll 100a as a projection roll and a lower caliber roll 100b as a groove roll. The fifth caliber K5 reduces a plate thickness to a thickness corresponding to that of a final product and performs rolling which decides a substantial plate thickness of the product. Besides, also regarding shapes of joint corresponding parts 8, 9 (hereinafter, joint shapes), rolling which decides a plate thickness of the joint is performed, and this almost decides a final product shape including the joint shapes. In more detail, the fifth caliber K5 performs the plate-thickness decision on the joint shapes, and the later-described sixth caliber K6 performs bending forming of the joint corresponding parts 8, 9. Note that the fifth caliber K5 is smaller in thickness reduction amount than the fourth caliber K4 which actively performs the thickness reduction of the whole material to be rolled A.

[0039] FIG. 7 is a schematic explanatory view of the caliber shape of the sixth caliber K6. As illustrated in FIG. 7, the sixth caliber K6 is composed of an upper caliber roll 110a as a projection roll and a lower caliber roll 110b as a groove roll, and the sixth caliber K6 performs bending forming of the joint corresponding parts 8, 9 of the material to be rolled A and shaping of the whole material to be rolled A by light reduction rolling. Specifically, joint forming of bending the whole joint corresponding parts 8, 9 into the joint shapes of the product is performed. Thus, the sixth caliber K6 forms the material to be rolled A up to the shape of the hat-shaped steel sheet pile product.

[0040] The caliber shapes and functions of the first caliber K1 to the sixth caliber K6 have been explained above referring to FIG. 2 to FIG. 7. As described above, the caliber rolling method for the hat-shaped steel sheet pile includes the rough rolling step, the intermediate rolling step, and the finish rolling step and, for example, the rough rolling step and the intermediate rolling step are performed in sequence in the calibers of the first caliber K1 to the fifth caliber K5, and the finish rolling step is performed in the sixth caliber K6. Here, all of the caliber shapes of the fourth caliber K4 to the sixth caliber K6 are in the substantially hat-shaped cross-sectional shape, and engraved in shapes closer to the product shape as they are calibers at later stages. In other words, the shape of the sixth caliber K6 where the finish rolling being the final step is performed is in the hat-shaped steel sheet pile product shape.

[0041] Note that the rough rolling mill (BD) 11, the intermediate rolling mill (R) 12, and the finish rolling mill (F) 14 are arranged in order on the rolling line S in this embodiment, and the above-described first caliber K1 to sixth caliber K6 are dispersedly engraved in an arbitrary configuration in the rolling mills. One example can be a configuration in which the first caliber K1 to the third caliber K3 are engraved in the rough rolling mill 11, the fourth caliber K4 and the fifth caliber K5 are engraved in the intermediate rolling mill 12, and the sixth caliber K6 is engraved in the finish rolling mill 14. However, the ca-

iber configuration in the present invention is not limited to such a configuration.

(Problems at rough rolling step)

[0042] The present inventors found problems as explained below regarding the rolling and shaping in the first forming caliber corresponding to the second caliber K2 in this embodiment at the rough rolling step in producing a hat-shaped steel sheet pile product having a larger size than conventional ones from the raw material B in the rectangular cross-sectional shape, and earnestly carried out studies on a technique for solving the problems.

[0043] Note that conventionally produced hat-shaped steel sheet pile products were, for example, each a product equal to or less than a size of a product called a so-called 25H product such as 900 mm in effective width $\times$ 300 mm in effective height. In contrast with this, the present inventors point at production of a product with such a size as exceeds 900 mm in effective width $\times$ 300 mm in effective height as the large-size hat-shaped steel sheet pile product. In producing the product with such a size, the problems as explained below are very remarkable, and important as problems that need to be solved.

[0044] First, because a height of a final product extends with an increase in size of the product, a rolling height in the second caliber K2 (first forming caliber) extends. In other words, in the rolling and shaping in the second caliber K2 (first forming caliber), a depressed height H with respect to the raw material B extends to increase a bending deformation amount of the raw material B.

[0045] Second, because a width of the final product extends with the increase in size of the product, a bending deformation moment arm L in the rolling and shaping in the second caliber K2 (first forming caliber) extends. Therefore, deformation in the rolling and shaping becomes deformation such that bending deformation is superior to shear deformation.

[0046] FIG. 8 is a schematic explanatory view illustrating a depressed height H with respect to the raw material B and a bending deformation moment arm L in the second caliber K2 (first forming caliber). The depressed height H illustrated in FIG. 8 indicates an amount to be reduced in a case of performing the rolling and shaping which forms a shape of the raw material B into a substantially hat-shaped cross-sectional shape in the second caliber K2 (first forming caliber), and there is a tendency that the larger a height of a final hat-shaped steel sheet pile product is, the more the depressed height H also extends.

[0047] Further, the bending deformation moment arm L illustrated in FIG. 8 is a moment arm in performing bending deformation in order to form a flange corresponding portion when a cross-sectional shape of the raw material B is formed from the rectangular cross-sectional shape into the substantially hat-shaped cross-sectional shape in the second caliber K2 (first forming cal-

iber), and there is a tendency that the larger a width of the final hat-shaped steel sheet pile product is, the more the bending deformation moment arm L also extends.

[0048] FIGs. 9 are schematic explanatory views illustrating conditions of reduction of the raw material B in the second caliber K2 (first forming caliber), and the conditions of reduction are illustrated in stages of (a) to (c). Further, the cross section of the raw material B is illustrated by a one-dotted chain line, and FIGs. 10(a) to (c) illustrate partially enlarged views of FIGs. 9 (dotted line portions in FIGs. 9). As illustrated in FIGs. 9, the rolling and shaping in the second caliber K2 (first forming caliber) can be indicated by being divided mainly into three stages. As illustrated in FIGs. 9(a) to (b), at a first stage, forming is performed in a state of bringing only a circumferential surface of a maximum diameter of the upper caliber roll 30a into contact with the raw material B, and the first stage is a stage preceding a start of thickness reduction of portions B1 corresponding to flanges of the raw material. At the first stage, the raw material B is not subjected to the thickness reduction, namely, the raw material B is only formed to be bent.

[0049] As illustrated in FIG. 9(b), a second stage indicates a condition from the start of the thickness reduction of the portions B1 corresponding to the flanges of the raw material to a stage preceding a start of thickness reduction of portions B2 corresponding to the arms of the raw material and a portion B3 corresponding to the web of the raw material, after the end of the above-described first stage. At the second stage, before the reduction of the portions B2 corresponding to the arms, the thickness reduction of only the portions B1 corresponding to the flanges of the raw material is started.

[0050] As illustrated in FIG. 9(c), a third stage indicates a stage of performing the thickness reduction of the whole raw material B (B1 to B3) (reduction of the whole surface) after the end of the above-described second stage.

[0051] In the rolling and shaping of being performed by being divided into the above-described first stage to third stage, the first stage is configured to only form the raw material B to be bent without being subjected to the thickness reduction, and at that time, to bring the circumferential surface of the upper caliber roll 30a into contact with the vicinity of the middle part of the raw material B (the portion B3 corresponding to the web) and not to bring the circumferential surface of the upper caliber roll 30a into contact with the other upper surface portion of the raw material B. In other words, at the first stage, the whole raw material B is formed in an unrestrained state, and the upper surface of the vicinity of the middle part thereof is pressed downward by the upper caliber roll 30a, to thus cause a drawing effect from the portions B2 corresponding to the arms of the raw material toward the portions B1 corresponding to the flanges and the portion B3 corresponding to the web. This decreases a material amount of the portions B2 corresponding to the arms of the raw material, resulting in that a phenomenon such as a material amount deficiency in the sections B2 is

seen. This causes gap parts 121, 122 in the vicinity of both end parts of the second caliber K2 (first forming caliber) as illustrated in FIG. 9(b). Such gap parts 121, 122 also remain at the third stage illustrated in FIG. 9(c), and it is found that rolling and shaping at a later stage is adversely affected.

[0052] FIG. 11(a) is a chart obtained by converting changes of a full width of upper surface t1 and a full width maximum t2 of the raw material B into numerals by FEM analysis when rolling and shaping of the raw material B in the second caliber 2K (first forming caliber) is performed in a plurality of passes. Further, FIG. 11(b) is an explanatory view of "full width of upper surface", "full width maximum", and "web gap". Note that the chart illustrated in FIG. 11(a) is the one when the rolling and shaping in the second caliber K2 (first forming caliber) is performed in a pass schedule described in Table 1 presented below by using a slab raw material with cross-sectional dimensions of 1930 mm × 300 mm. Here, as illustrated in FIG. 11(b), the "full width of upper surface t1" of the raw material B in the rolling and shaping is defined as a value of a full width decided in contact with the upper caliber roll 30a, and the "full width maximum t2" is defined as a value of a full width decided in contact with the lower caliber roll 30b.

[Table 1]

PASS	WEB GAP
1	584
2	509
3	434
4	359
5	336
6	314
7	291
8	269
9	246
10	224
11	201
12	179
13	161
14	144
15	128
16	111

[0053] As a premise, it is said to be in an ideal deformed state that the numeric values of the full width of upper surface t1 and the full width maximum t2 have no difference and always coincide with each other. However, as illustrated in FIG. 11(a), with progress of the rolling and

shaping passes in the second caliber K2 (first forming caliber), in particular, the full width of upper surface t1 varies greatly, and for example, a thickness deficiency occurs in a range of the degree of about 50 mm from an end part in the final pass (the 16th pass in Table 1). This is attributed to the fact that the material amount of the portions B2 corresponding to the arms decreases accompanying the rolling and shaping (forming) to cause the material amount deficiency as described above referring to FIGs. 9, 10.

[0054] Further, in the pass schedule presented in Table 1, in particular, a variation range (decrease range) is large during the passes up to a start of the thickness reduction of the portions B1 corresponding to the flanges (the first to fourth passes). This is because the first pass to the fourth pass are at the stage where the raw material B is not subjected to the thickness reduction but subjected to the bending deformation in addition to the shear deformation.

[0055] On the other hand, in an eighth and subsequent passes of the pass schedule presented in Table 1, widening occurs due to the thickness reduction of the portions B2 corresponding to the arms of the raw material, and the full width of upper surface t1 turns to an increase, but the rolling and shaping in the second caliber K2 (first forming caliber) is ended without completely eliminating the material amount deficiency also in the final pass.

(Edging rolling for solving problems and operation and effect thereof)

[0056] As explained above referring to FIGs. 9 to 11, in producing the large-size hat-shaped steel sheet pile product, there occurs the material amount deficiency of the portions B2 corresponding to the arms in the rolling and shaping in the second caliber K2 (first forming caliber), and as a result, there is a possibility of causing a shape defect of a product accompanying the material amount deficiency in arm parts of the product.

[0057] Thus, the present inventors earnestly carried out studies, and obtained findings that can eliminate the material amount deficiency of the portions B2 corresponding to the arms by rolling and shaping the raw material B in a dog-bone shape after edging rolling and shaping in the second caliber K2 (first forming caliber), after using a rectangular cross-sectional raw material (slab) having a width larger than a caliber width of the second caliber K2 (first forming caliber) and performing rolling and shaping under predetermined conditions in the edging caliber (the first caliber K1 in this embodiment) being at a preceding stage of the second caliber K2 (first forming caliber). Hereinafter, the findings will be explained referring to the drawings and so on.

[0058] Note that the "dog-bone shape" in this description means a state where a thickness of both-side end parts in the width direction is deformed into a larger shape relative to a middle part in the width direction as compared with a rectangular cross-section, and means a rec-

tangular cross-sectional raw material, what is called, deformed into a double bulging shape.

[0059] FIGs. 12 are schematic views when the edging rolling is performed on the raw material B having a width larger than that of the second caliber K2 (first forming caliber) to increase the thickness of end parts in the width direction (upper and lower both end parts in the drawing) in the edging caliber. FIG. 12(a) illustrates a cross section of a material to be rolled (raw material B) in the dog-bone shape, what is called, deformed into a double bulging shape, and FIG. 12(b) is the one obtained by enlarging a part of the cross section. Concretely, as shown in the illustrations, a slab thickness is indicated with T1, and a restraining caliber such that a width of a caliber bottom surface (caliber bottom width) T3 is larger than the slab thickness T1 (namely, $T1 < T3$) is used as the edging caliber with respect to the raw material B having a width larger than a width of the second caliber K2 (first forming caliber). Then, in the edging caliber, by performing such edging rolling as makes a maximum thickness of the end parts in the width direction of the raw material B to be T2, it is possible to suppress the material amount deficiency of the portions B2 corresponding to the arms in the second caliber K2 (first forming caliber). Here, as illustrated in FIG. 12(b), the maximum thickness T2 of the raw material B after the edging rolling is set to be a value larger than those of both the slab thickness T1 and the caliber bottom width T3 ($T1 < T3 < T2$).

[0060] Besides, in the width direction (vertical direction in FIGs. 12) of the raw material B, when a range in which the thickness is increased more than the slab thickness T1 is defined as Wa, the material amount deficiency of the portions B2 corresponding to the arms in the second caliber K2 (first forming caliber) is suppressed by the edging rolling, while, from the viewpoint of prevention of metal extrusion (so-called "biting-out") from the caliber due to a material amount excess, the above-described range Wa is preferably set as a range corresponding to a part or the whole of a width Wb (illustrated in FIGs. 13) of the portion B2 corresponding to the arm of the raw material in the second caliber K2 (first forming caliber). In other words, the relation of $Wa \leq Wb$ is preferably satisfied. This is attributed to the fact that, when the rolling and shaping in the second caliber K2 (first forming caliber) is considered to be divided into the three stages, it is found that the drawing effect occurs from the portions B2 corresponding to the arms of the raw material toward the portions B1 corresponding to the flanges and the portion B3 corresponding to the web at the first stage, in particular, it is found that the material amount of the portions B2 corresponding to the arms of the raw material decreases to cause the phenomenon such as a material amount deficiency in the sections B2 at the first stage, as described above referring to FIGs. 9, 10.

[0061] Note that in a case of measuring or defining the above values such as T1, T2, T3 and the ranges such as Wa, Wb, it is only necessary to, at each corner part having a predetermined curvature of a caliber circumfer-

ential surface of the first caliber K1 or the second caliber K2, measure or define the dimensions using, as a reference, an intersection point when virtual lines are drawn on both-side portions of the corner part. For example, as illustrated in FIG. 12(b), in a case of defining the caliber bottom width T3 of the edging caliber, or in a case of measuring the range Wa to increase the thickness, it is only necessary to use, as a reference, PI being an intersection point of extending virtual lines on a side surface and a bottom surface of the edging caliber.

[0062] Here, when such edging rolling as makes a maximum thickness of the end parts in the width direction to be T2 ($> T1$) is performed on the raw material B having the slab thickness of T1 and having a width larger than that of the second caliber K2 (first forming caliber), T2 and T1 preferably have a predetermined relationship. It is desired that the preferable relationship between T2 and T1 is preferably decided based on changes in the full width of upper surface t1 and the full width maximum t2 of the raw material B described later referring to FIG. 15.

[0063] FIGs. 13 are schematic explanatory views comparing a cross section in the rolling and shaping in the second caliber K2 (first forming caliber) when the thickness of the end part in the width direction of the raw material in the edging rolling according to the present invention is increased, and, a cross section in the rolling and shaping in the second caliber K2 (first forming caliber) when the raw material has a conventional rectangular cross-section as it is, (a) is the cross section in application of the present invention, and (b) is the cross section in application of the conventional rectangular cross-section. Note that FIGs. 13 are the cross sections in each starting the thickness reduction of the portion B1 corresponding to the flange of the raw material, (a) and (b) illustrate a state of having the same roll gap, and only a part of each of the cross sections is enlarged for convenience of explanation.

[0064] As illustrated in FIG. 13(b), in the rolling and shaping of the conventional rectangular cross-section in the second caliber K2 (first forming caliber), the reduction of the portion B2 corresponding to the arm is not started at the stage of starting the reduction of the portion B1 corresponding to the flange. On the other hand, as illustrated in FIG. 13(a), in the rolling and shaping in the second caliber K2 (first forming caliber) in the application of the present invention, the reduction of the portion B2 corresponding to the arm is started at almost the same timing as the stage of starting the reduction of the portion B1 corresponding to the flange, and the full width of upper surface t1 turns to an increase due to the thickness reduction of the arm in subsequent deformation.

[0065] FIG. 14 is a schematic view comparing cross-sectional shapes of the materials to be rolled at a time of completion of the rolling and shaping in the second caliber K2 (first forming caliber), a hatching portion indicates the cross section in the application of the present invention, and a solid line indicated in a section surround-

ed by a dotted line indicates a portion deficient in the material amount in the conventional cross section, and in particular, the vicinity of the portions B2 corresponding to the arms of the materials to be rolled is enlarged to be illustrated. As illustrated in FIG. 14, after applying the present invention and increasing the thickness of the end part in the width direction of the raw material in the edging rolling, by performing the rolling and shaping in the second caliber K2 (first forming caliber), it is found that the material amount deficiency of the portion B2 corresponding to the arm is suppressed and eliminated (refer to a dotted-line surrounded portion in FIG. 14).

[0066] Further, FIG. 15 is a chart obtained by converting changes of full widths of upper surfaces t1 and full width maximums t2 of raw materials B into numerals by FEM analysis when the rolling and shaping of the raw materials B in the second caliber K2 (first forming caliber) is performed in a plurality of passes after performing the edging rolling on slabs each having a width larger than a width of the second caliber K2 (first forming caliber) to increase the thickness of end parts in the width direction of the raw material. Note that FIG. 15 illustrates graphs each of when the rolling and shaping in the second caliber K2 (first forming caliber) is performed after performing the edging rolling on the slab having a width 100 mm larger than a width of the second caliber K2 (first forming caliber) (namely, 2030 mm × 300 mm raw material), and, when the rolling and shaping in the second caliber K2 (first forming caliber) is performed after performing the edging rolling on the slab having a width 50 mm larger than a width of the second caliber K2 (first forming caliber) (namely, 1980 mm × 300 mm raw material), and also illustrates graphs (similar to graphs in FIG. 11) in the case of no application of the present invention (conventional method) together for reference purposes. Besides, the pass schedule of the rolling and shaping is the pass schedule described in the above-described Table 1.

[0067] As illustrated in FIG. 15, it is perceived that when the rolling and shaping in the second caliber K2 (first forming caliber) is performed after extending the width of each of the slabs to be used and increasing the thickness of the portions corresponding to the arms in bulging by the edging rolling, the increase in the thickness of the portions corresponding to the arms brings deformation which promotes drawing of metal to flange sides in the passes at a preceding stage (for example, the first pass to the fifth pass), but as described above referring to FIGs. 13 and so on, there is a tendency that a rise (recovery) of the full width of upper surface t1 in the passes at a later stage (for example, the sixth and subsequent passes) is remarkable because the reduction start of the portions corresponding to the arms is accelerated. In particular, when the rolling and shaping in the second caliber K2 (first forming caliber) is performed after performing the edging rolling on the slab having a width 100 mm larger than a width of the second caliber K2 (first forming caliber), it is found that the full width of upper surface t1 rises up to a value coinciding with a value of the full width

maximum t2 in the final pass, to realize the recover of the material amount deficiency.

[0068] FIG. 15 describes the schedule in which the rolling and shaping is performed in the total 16 passes (refer to Table 1), and an ideal deformed state in the final pass (the 16th pass) is a deformation such that the full width of upper surface t1 and the full width maximum t2 coincide with each other (refer to the hatching portion in FIG. 14).

[0069] When a slab width is too large and a reduction amount in the edging rolling is too much, metal extrudes from the caliber, so-call "biting-out" occurs, as in FIG. 16, which has a possibility of leading to a defect such as a product flaw (refer to a dotted line portion in FIG. 16). Under the condition that the slab having a width 100 mm larger than a width of the second caliber K2 (first forming caliber) illustrated in FIG. 15 is used, the material amount is excessive because the full width maximum t2 < the full width of upper surface t1 is obtained in the final pass. On the other hand, under the condition that the slab having a width 50 mm larger than the width of the second caliber K2 (first forming caliber) illustrated in FIG. 15 is used, the full width maximum t2 > the full width of upper surface t1 is obtained in the final pass, resulting in the material amount deficiency. It is found from the results of the studies as above that a dimension condition of an appropriate slab for realizing the ideal deformed state is a condition that a width of the slab is larger than the width of the second caliber K2 (first forming caliber) by more than 50 mm and less than 100 mm.

[0070] Note that it is only necessary for the width of the second caliber K2 (first forming caliber) to be calculated based on product dimensions (particularly a product width) of the final hat-shaped steel sheet pile product, for example, to be defined as a width length obtained by adding a thickness portion of a joint part and a bent portion of the joint part to the product width.

[0071] As explained above referring to FIG. 12 to FIG. 16, by adopting the method of performing the rolling and shaping of the raw material B in the second caliber K2 (first forming caliber) after performing the edging rolling on the slab having a width larger than a width of the second caliber K2 (first forming caliber) to increase the thickness of the end parts in the width direction of the raw material, there is solved the problem that in producing the large-size hat-shaped steel sheet pile product, the material amount deficiency of the portions B2 corresponding to the arms occurs in the rolling and shaping in the second caliber K2 (first forming caliber), resulting in causing the shape defect of the product accompanying the material amount deficiency in the arm parts of the product. In other words, it becomes possible to stably produce a hat-shaped steel sheet pile product in a good shape.

[0072] In that case, when the thickness of the end parts in the width direction of the raw material is increased in the edging rolling, the range Wa in which the thickness is increased is preferably smaller than the width Wb of the portion B2 corresponding to the arm of the raw ma-

material in the second caliber K2 (first forming caliber). It is found that the material amount deficiency in the arm parts of the product can be sufficiently eliminated by satisfying the relation of $W_a \leq W_b$.

[0073] One example of the embodiment of the present invention has been described above, but the present invention is not limited to the illustrated embodiment. It should be understood that various changes and modifications are readily apparent to those skilled in the art within the scope of the spirit as set forth in claims, and those should also be covered by the technical scope of the present invention.

[0074] In the above-described embodiment, as the configurations of the calibers engraved in the rolling mills, there is cited a configuration in which the first caliber K1 to the third caliber K3 are engraved in the rough rolling mill 11, the fourth caliber K4 and the fifth caliber K5 are engraved in the intermediate rolling mill 12, and the sixth caliber K6 is engraved in the finish rolling mill 14, but the engraving of the calibers in the respective rolling mills in the present invention can be arbitrarily decided.

[Industrial Applicability]

[0075] The present invention is applicable to a production method for producing a hat-shaped steel sheet pile from a rectangular cross-sectional raw material.

[Explanation of Codes]

[0076]

3	web corresponding part	
4, 5	flange corresponding part	
6, 7	arm corresponding part	35
8, 9	joint corresponding part	
11	rough rolling mill	
12	intermediate rolling mill	
14	finish rolling mill	
32, 42	web facing part (of second caliber)	40
34, 35, 44, 45	flange facing part (of second caliber)	
37, 38, 47, 48	arm facing part (of second caliber)	
A	material to be rolled	
B	raw material	
K1 to K6	first caliber to sixth caliber	45
S (S1 to S3)	rolling line	

Claims

1. A production method for producing a hat-shaped steel sheet pile by reducing a rectangular cross-sectional raw material, the production method comprising:

edging rolling of performing reduction in a width direction on the rectangular cross-sectional raw material; and

a first forming rolling of performing reduction in which a cross section of a material to be rolled after the edging rolling is formed into a substantially hat-shaped cross-sectional shape, wherein in the edging rolling, reduction in which a thickness of end parts in the width direction of the material to be rolled is increased using an edging caliber being a restraining caliber having a caliber bottom width T3 larger than a thickness T1 of the rectangular cross-sectional raw material to form into a dog-bone shape is performed.

2. The production method for the hat-shaped steel sheet pile according to claim 1, wherein in the edging rolling, a range W_a in which a thickness is increased in the width direction of the rectangular cross-sectional raw material is set as a range corresponding to a part or a whole of a width W_b of a portion corresponding to an arm of the material to be rolled in the first forming rolling.

3. The production method for the hat-shaped steel sheet pile according to claim 2, wherein in the edging rolling, the range W_a in which a thickness is increased in the width direction of the rectangular cross-sectional raw material is defined by a portion having a thickness larger than the caliber bottom width T3 of the edging caliber, and wherein a relation between the range W_a in which a thickness is increased in the width direction of the rectangular cross-sectional raw material and the width W_b of the portion corresponding to the arm of the material to be rolled in the first forming rolling satisfies $W_a \leq W_b$.

FIG.1

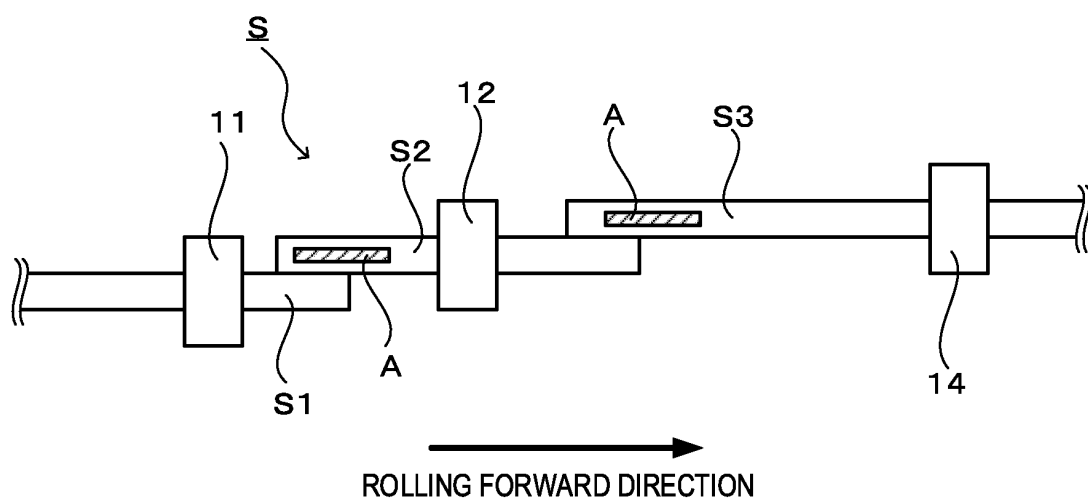


FIG.2

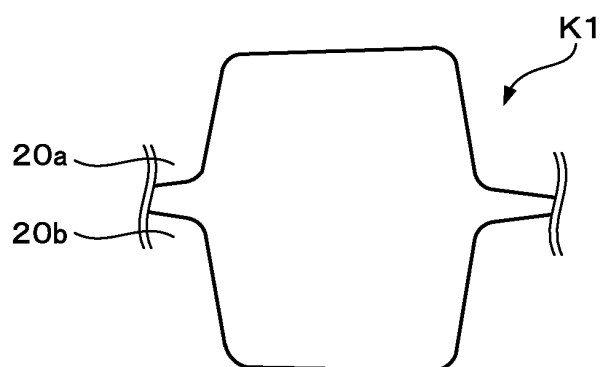


FIG.3

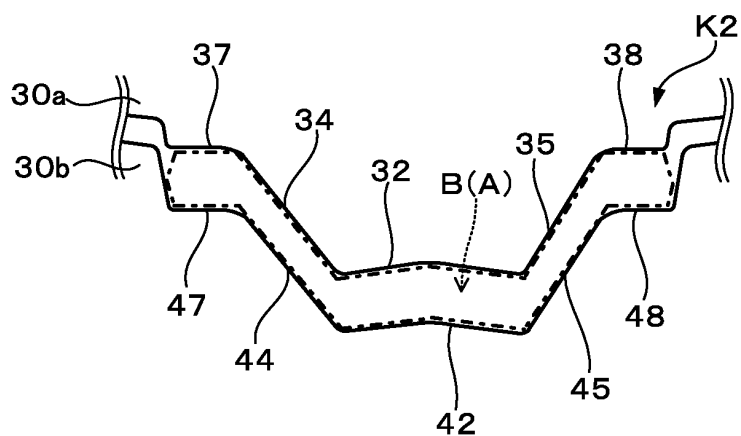


FIG.4

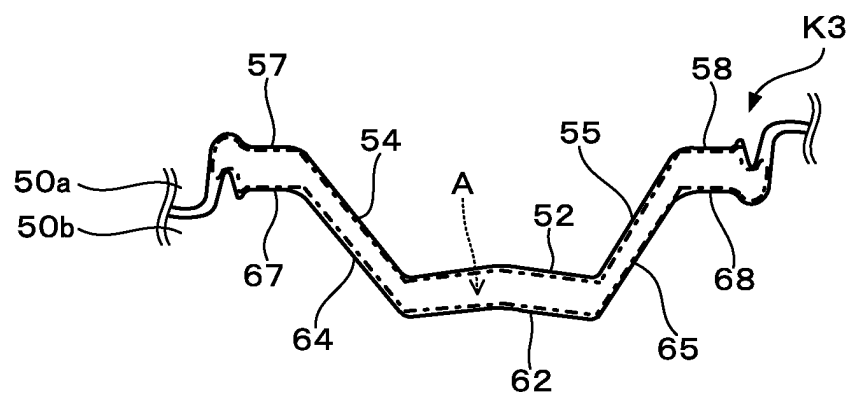


FIG.5

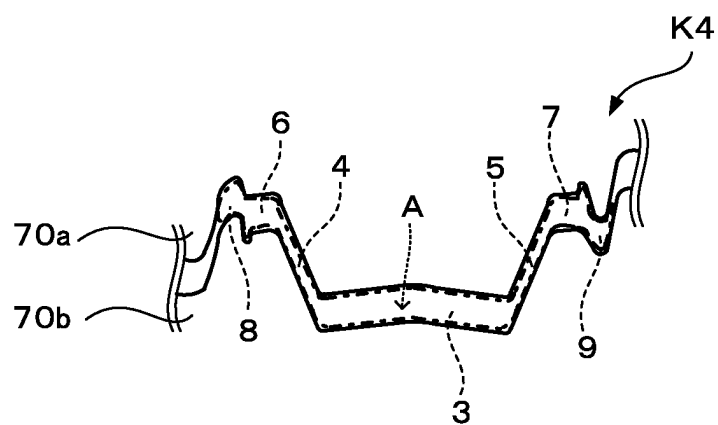


FIG.6

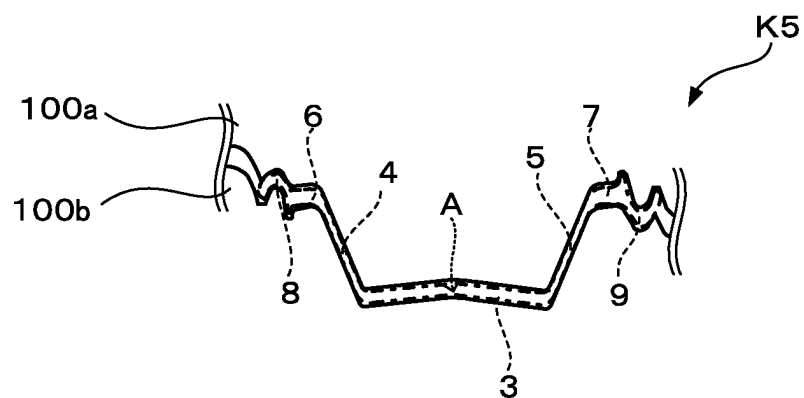


FIG.7

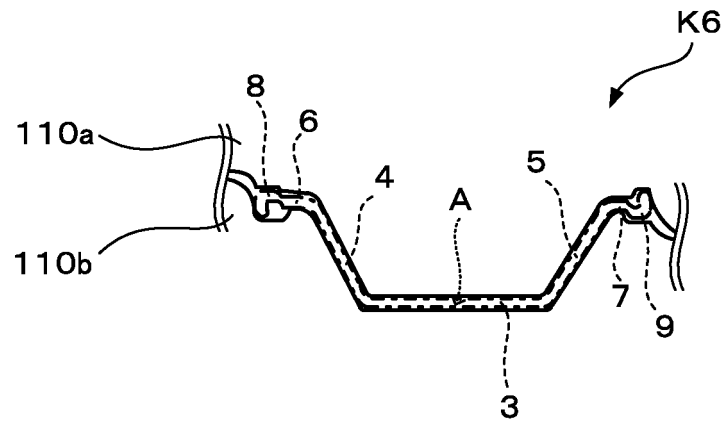


FIG.8

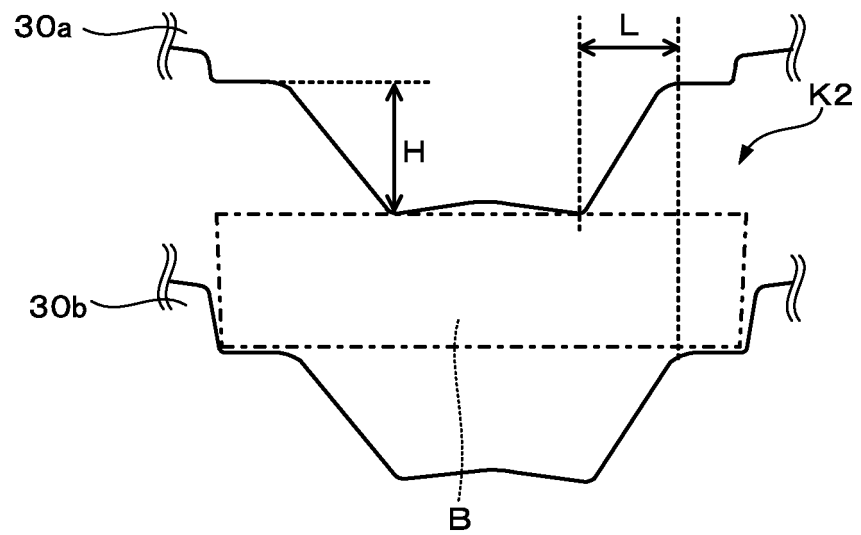
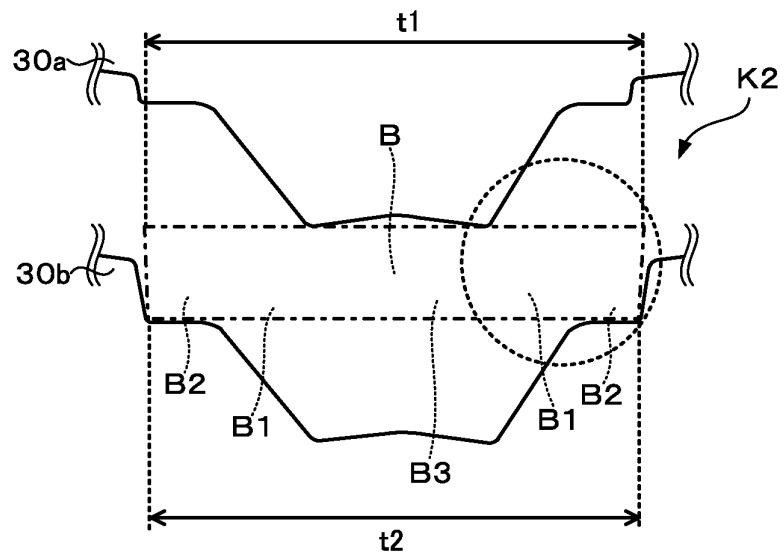
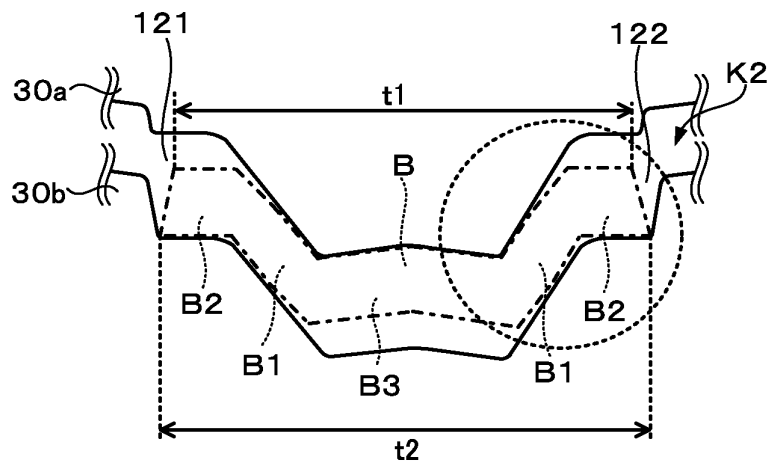


FIG.9
(a)



(b)



(c)

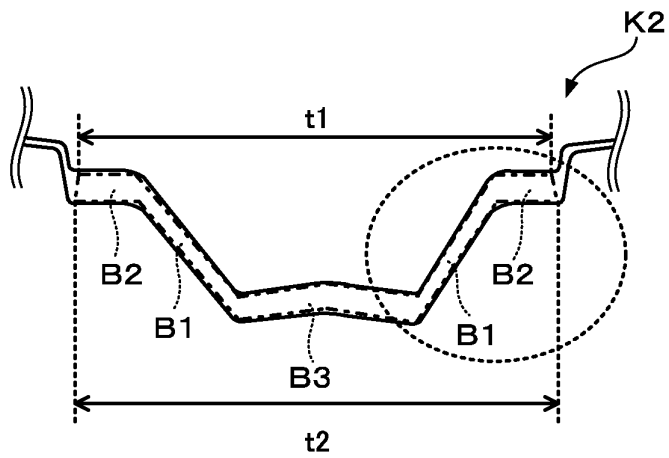
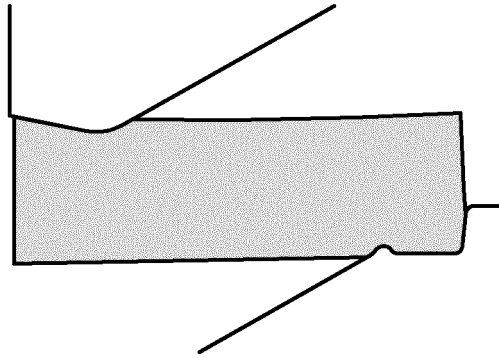
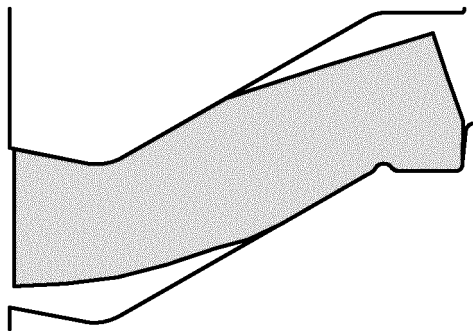


FIG.10
(a)



(b)



(c)

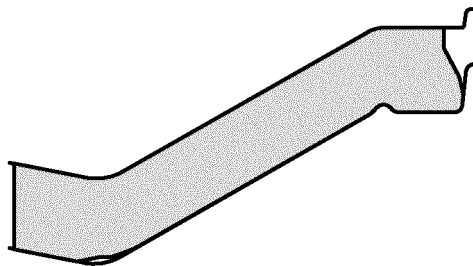


FIG.11

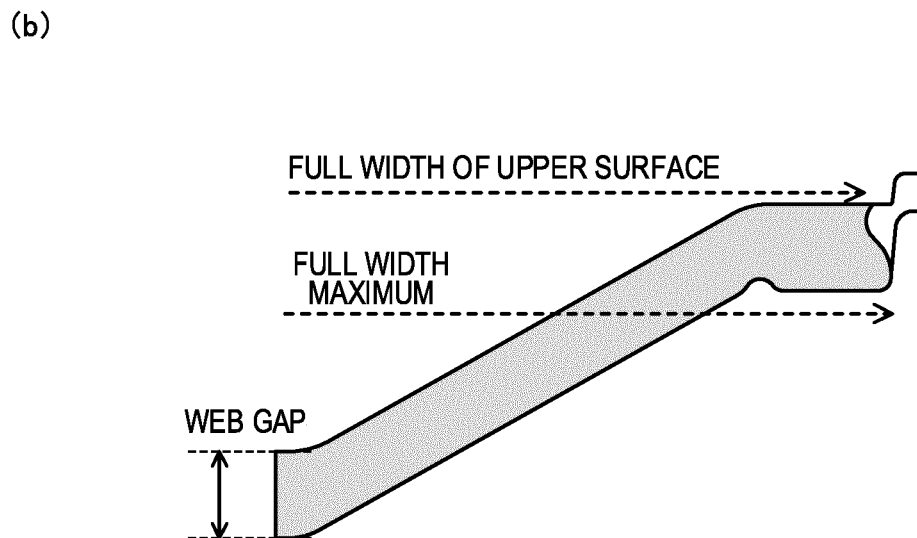
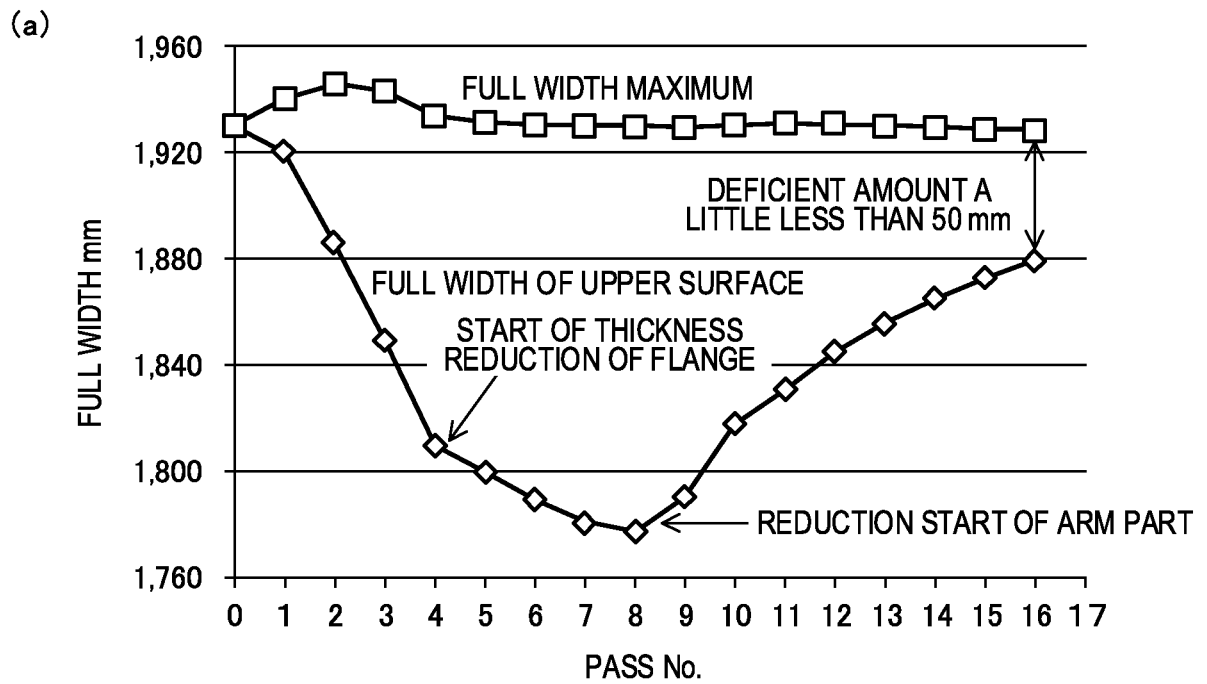
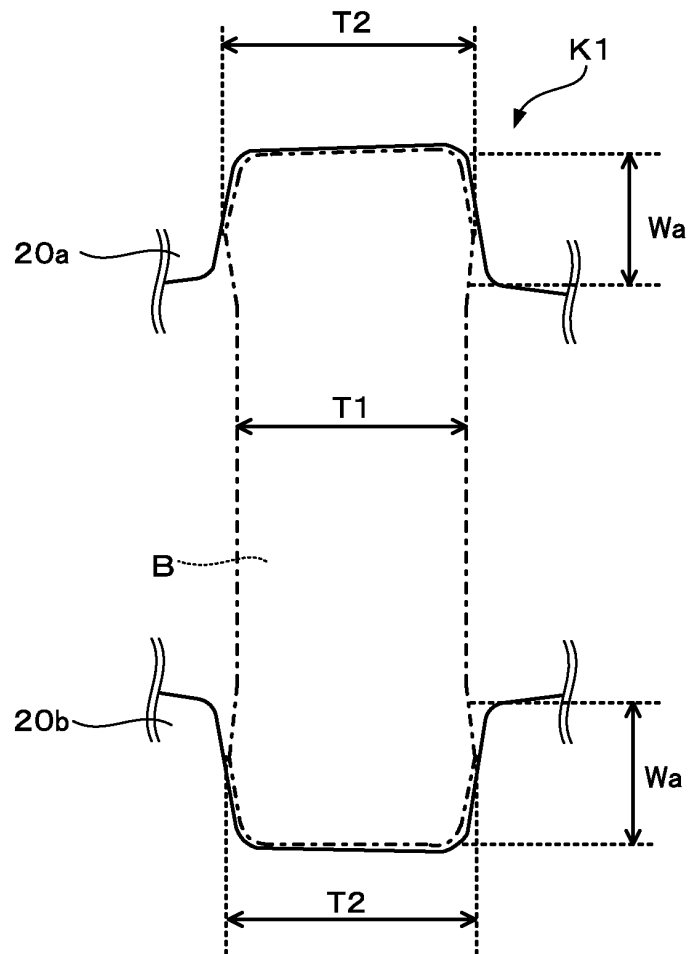


FIG.12

(a)



(b)

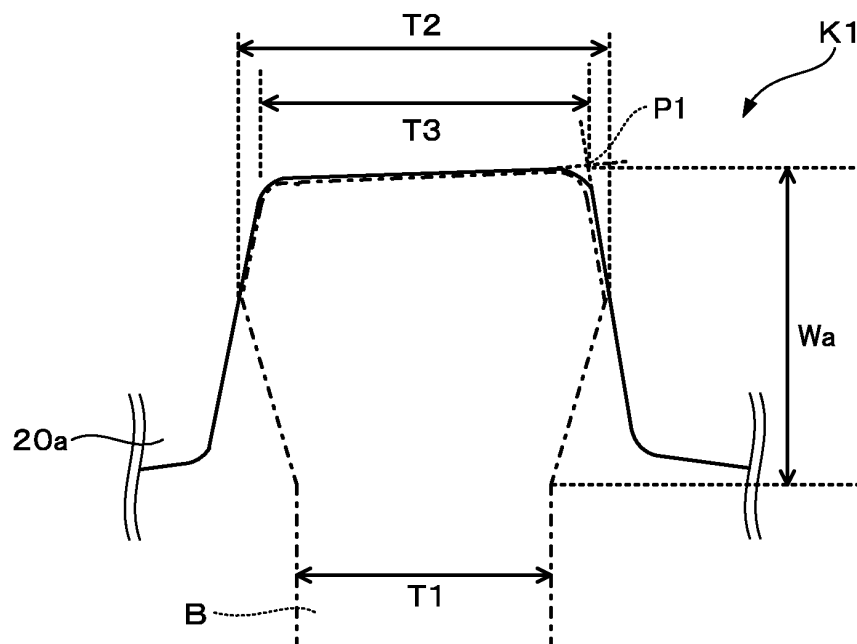


FIG.13

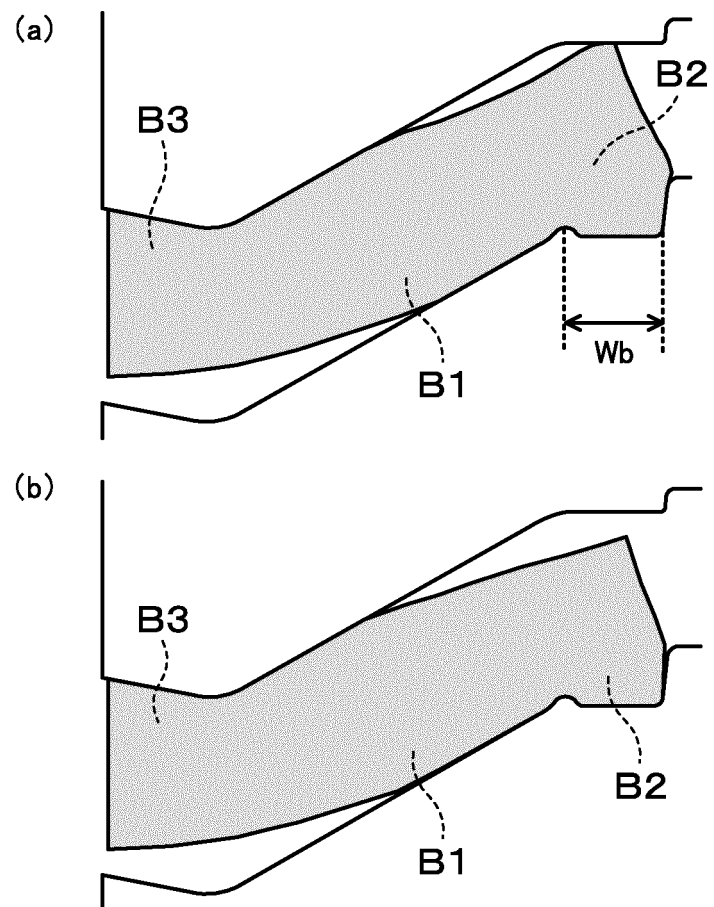


FIG.14

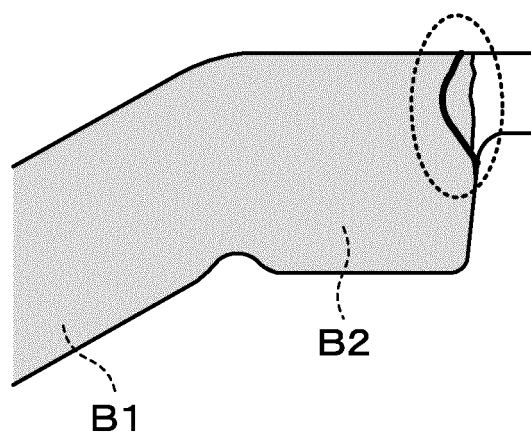


FIG.15

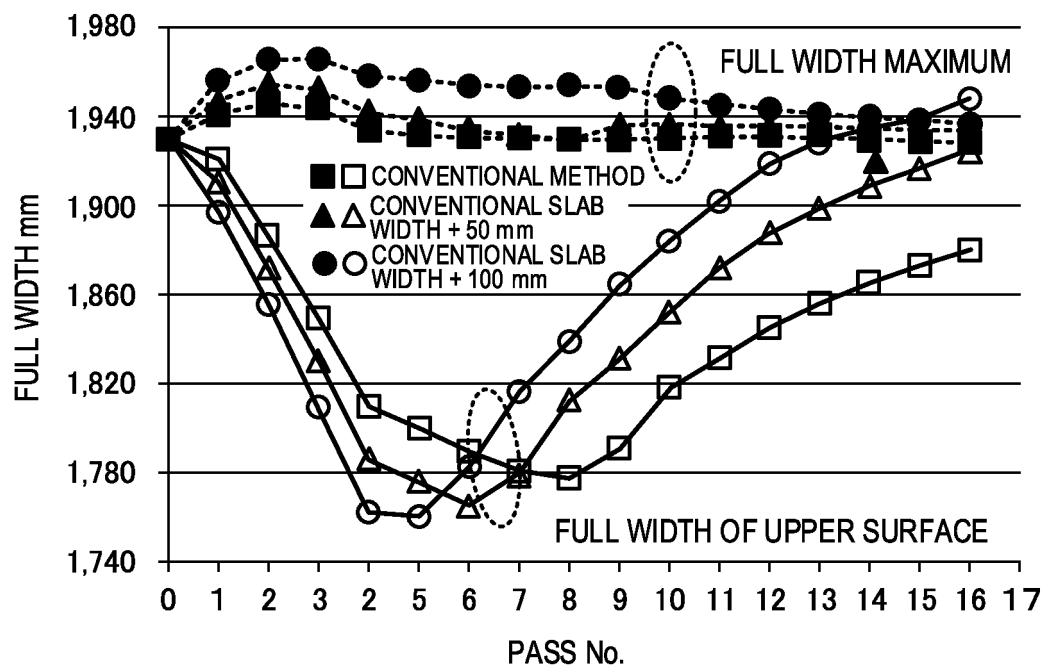
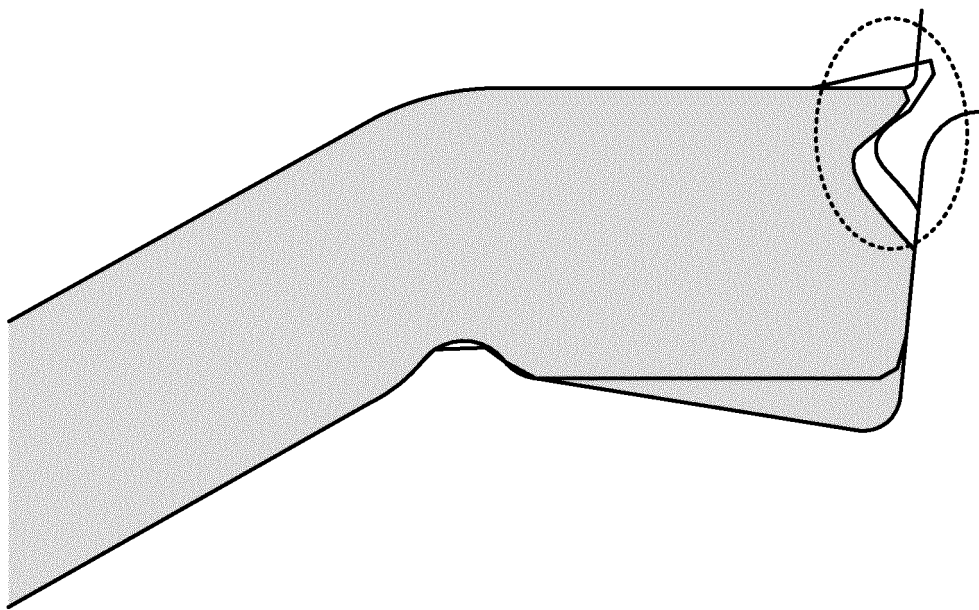


FIG.16



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/031445

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. B21B1/08 (2006.01) i, B21B1/082 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. B21B1/00-11/00, B21B47/00-99/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2019

Registered utility model specifications of Japan 1996-2019

Published registered utility model applications of Japan 1994-2019

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2018/139521 A1 (NIPPON STEEL & SUMITOMO METAL CORPORATION) 02 August 2018, entire text, all drawings (Family: none)	1-3
A	JP 7-178402 A (NKK CORP.) 18 July 1995, entire text, all drawings (Family: none)	1-3
A	JP 58-65501 A (KAWASAKI STEEL CORP.) 19 April 1983, entire text, all drawings (Family: none)	1-3



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search
07 October 2019 (07.10.2019)Date of mailing of the international search report
15 October 2019 (15.10.2019)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/031445

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 5-329502 A (NIPPON STEEL CORP.) 14 December 1993, entire text, all drawings (Family: none)	1-3
A	JP 2-34201 A (NIPPON STEEL CORP.) 05 February 1990, entire text, all drawings (Family: none)	1-3

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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