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bonding a reinforcement to part of the metal sheet and then forming the metal sheet.

Description

Technical Field

5 **[0001]** The present invention relates to a method of forming a metal sheet in which no breakage occurs during forming such as by drawing, stretch flanging, bending, and stretch forming and a formed part formed by that method of forming.

Background Art

10 **[0002]** Usually, the formability of a metal sheet falls the more the strength of the metal sheet rises. For this reason, when forming a particularly high strength metal sheet, if the portion to be formed cannot plastically deform enough, the internal stress will exceed the breaking yield strength and the sheet will break.

[0003] FIG. 1 shows a mode of breakage at a shoulder part of a punch when drawing a metal sheet. The blank material 1 of the metal sheet is drawn by pressing a flange part 1' of a blank material 1 in a die 2 by a blank holder 4 while pressing it by a punch 3. Drawing proceeds by a balance of a breaking yield strength of the blank material 1 at the shoulder part 15 3' of the punch 3 and the pulling force acting on the flange part 1' of the blank material 1.

[0004] Further, when a deformation resistance 6 of the flange part 1' becomes equal to the breaking yield strength of the blank material 1 contacting the shoulder part 3' of the punch 3, the flange part 1' stops deforming (being pulled into the die 2). On the other hand, deformation proceeds at only the portion of the blank material 1 contacting the shoulder 20 part 3' of the punch 3 resulting in breakage.

[0005] To avoid breakage when drawing a blank material, a high breaking yield strength of the portion contacting the shoulder part of the punch is important. Up until now, several arts have been proposed for preventing breakage of a blank material at the time of a drawing operation.

25 **[0006]** PLT 1 proposes a method of press-forming a blank material during which a location of the blank material where a reduction in thickness is anticipated is provided with two or more weld beads and then the press-forming operation is performed.

[0007] PLT 2 proposes a tailored blank material for press-forming use excellent in deep drawability obtained by welding a high strength steel sheet having a 15% or more lower strength and sheet thickness than the material at a center part or a 5% or more better ductility than the material of the center part with another steel sheet forming the center part over 30 the entire circumference of a drawn flange part at a part imparting a wrinkle suppressing force at the time of forming at the outside the part becoming the final product after deep drawing.

[0008] However, in each of the above arts, at the weld input heat part of the blank material, the material becomes brittle and the material of the blank material becomes uneven, so it is difficult to completely avoid breakage of the blank material at the time of a press-forming operation.

Citation List

Patent Literature

40 **[0009]**

PLT 1. Japanese Patent Publication No. 10-175024A

PLT 2. Japanese Patent No. 4532709B

45 Summary of Invention

Technical Problem

50 **[0010]** In general, as techniques for preventing breakage when forming a metal sheet, roughly classified, improvement of the forming process and improvement of the material of the metal sheet may be considered. For example, for improvement of the drawing process, the method of division of the dies and increase of the number of pressing processes may be considered, but with these methods, a rise in the forming costs and fall in the productivity are unavoidable.

[0011] PLTs 1 and 2 disclose improvement of the material of the high strength steel sheet by changing (strengthening) the material by partial hardening or bonding with different materials. However, with these methods as well, similarly, a 55 rise in the forming costs and fall in the productivity are unavoidable.

[0012] Therefore, the present invention has as its problem preventing a metal sheet from breaking when forming a metal sheet without changing the material of the metal sheet and the forming process and has as its object the provision of a method of forming solving that problem and a formed part formed by that method of forming.

Solution to Problem

[0013] The inventors studied in-depth means for solving the above problem. As a result, the inventors discovered that when forming a metal sheet, if bonding a reinforcement to a portion where breaking yield strength is required, the breaking yield strength at the above portion is improved and breakage can be prevented.

[0014] The present invention was made based on the above discovery and has as its gist the following:

(1) A method of forming a metal sheet comprising the steps of bonding a reinforcement with a part of the metal sheet and then forming the metal sheet.

(2) The method of forming a metal sheet according to (1), wherein the reinforcement is bonded with a portion of the metal sheet reduced in thickness in the forming process.

(3) The method of forming a metal sheet according to (1) or (2), wherein the metal sheet is a high strength steel sheet having a tensile strength of 590 MPa or more.

(4) The method of forming a metal sheet according to any one of (1) to (3), wherein the reinforcement is a fiber reinforced plastic.

(5) The method of forming a metal sheet according to (4), wherein the fiber reinforced plastic is bonded so that the direction of the fibers runs along the direction in which the breaking strength of the metal sheet is required.

(6) The method of forming a metal sheet according to any one of (1) to (3), wherein the reinforcement is a high strength steel foil.

(7) A formed part drawn by the method of forming of a high strength steel sheet according to any one of (1) to (6).

Advantageous Effects of Invention

[0015] According to the present invention, when forming a metal sheet, it is possible to raise the breaking yield strength of a portion where breaking yield strength is required, improve the formability of the metal sheet, and prevent breakage during drawing without changing the material of the metal sheet and the forming process.

Brief Description of Drawings

[0016]

FIG. 1 is a view showing a mode of breakage at a shoulder part of a punch when drawing high strength steel sheet. FIG. 2 is a view showing a mode of preventing breakage by bonding a sheet of fiber reinforced plastic with a portion where breaking yield strength is required when drawing high strength steel sheet.

FIGS. 3A and 3B are views showing a mode of bonding a reinforcement comprised of fiber reinforced plastic with a portion where breaking yield strength is required when drawing a high strength steel sheet. FIG. 3A shows the mode of bonding ring-shaped fiber reinforced plastic to a ring-shaped portion where breaking yield strength is required, while FIG. 3B shows a cross-section of a formed part obtained by drawing the blank material shown in FIG. 3A.

FIGS. 4A and 4B are views showing another mode of bonding a reinforcement comprised of fiber reinforced plastic with a portion where breaking yield strength is required when drawing a high strength steel sheet. FIG. 4A shows the mode of bonding ring-shaped fiber reinforced plastic to two ring-shaped portions where breaking yield strength is required, while FIG. 4B shows a cross-section of a formed part obtained by drawing the blank material shown in FIG. 4A.

FIG. 5 is a view showing a mode of bonding reinforcements comprised of divided patches of ring-shaped fiber reinforced plastic at a ring-shaped portion where breaking yield strength is required.

FIG. 6 is a view showing the position of a punch shoulder expected to become a portion where breakage in deep drawing is a concern.

FIG. 7 is a view showing the position of a flange end expected to become a portion where breakage in stretch flanging is a concern.

FIG. 8 is a view showing a position of bending expected to become a portion where breakage in bending is a concern.

FIG. 9 is a view showing a position of a punch stretching portion expected to become a portion where breakage in stretch forming is a concern.

FIG. 10 is a chart showing the flow for determining the position where the reinforcement is bonded when forming a metal sheet of a complicated shape where it is difficult to predict a portion where breaking yield strength will be required.

FIG. 11 is a view showing a method of bonding a sheet of fiber reinforced plastic with a portion of high strength steel sheet where breaking yield strength is required.

FIGS. 12A and 12B are views showing the case of a drawing operation without a sheet of fiber reinforced plastic bonded to a portion where breaking yield strength is required when drawing high strength steel sheet and the case of a drawing operation with a sheet of fiber reinforced plastic bonded. FIG. 12A shows the case of a drawing operation without bonding a sheet of fiber reinforced plastic with a portion where breaking yield strength is required, while FIG. 12B shows the case of a drawing operation while bonding a sheet of fiber reinforced plastic with a portion where breaking yield strength is required.

Description of Embodiments

[0017] The method of forming a metal sheet of the present invention is a method of forming a metal sheet comprising drawing a sheet with a reinforcement bonded in advance to a portion where breaking yield strength is required (below, referred to as "a portion where breakage is a concern").

[0018] The formed part of the present invention is characterized by being formed by the method of forming of the present invention.

[0019] The method of forming of the present invention will be explained based on the drawings.

[0020] FIG. 2 shows as one example of the present invention a mode of drawing a high strength steel sheet wherein a sheet of fiber reinforced plastic is bonded with a portion where breaking yield strength is required so as to prevent breakage.

[0021] A blank material 1 of a high strength steel sheet is drawn by pressing a flange part 1' of the blank material 1 in a die 2 by a blank holder 4 while pressing it by a punch 3. Drawing proceeds by a balance of the breaking yield strength of the blank material 1 at the shoulder part 3' of the punch 3 and the pulling force acting on the flange part 1' of the blank material 1.

[0022] Further, as explained above, when a deformation resistance 6 of the flange part 1' becomes equal to the breaking yield strength of the blank material 1 contacting the shoulder part 3' of the punch 3, the flange part 1' stops deforming (being pulled into the die 2). On the other hand, deformation proceeds at only the portion of the blank material 1 contacting the shoulder part 3' of the punch 3 resulting in breakage (see FIG. 1).

[0023] On the other hand, when drawing high strength steel sheet shown in FIG. 2, a reinforcement comprised of a sheet of fiber reinforced plastic 8 is bonded in advance with a portion 7 where breaking yield strength is required and then the drawing operation is performed.

[0024] In drawing the blank material 1, if bonding a sheet of fiber reinforced plastic 8 with a portion where breakage during drawing is a concern, that is, the portion 7 where breaking yield strength is required, the breaking yield strength is improved at the portion 7 where breaking yield strength is required and the blank material 1 will not break during drawing.

[0025] FIG. 2 shows a mode of bonding a fiber reinforced plastic sheet 8 so as to surround a bottom part of a drawn part so that during drawing of high strength steel sheet, the fiber reinforced plastic sheet 8 reliably bonds with the portion 7 where breaking yield strength is required and can sufficiently exert the function of improving the breaking yield strength. The mode of bonding the reinforcement to the portion where breaking yield strength is required is not limited to the mode of bonding shown in FIG. 2. Various modes of bonding can be employed so long as reliably bonding the reinforcement with the portion where breaking yield strength is required. This point will be explained later while showing another bonding mode.

[0026] The technique of bonding with a formed part a sheet or patch of carbon fiber reinforced plastic (CFRP) formed separately matching the shape of the formed part to improve the mechanical properties or functionality of the formed part or reinforce it has been known (for example, see FY2010 Report on Project for Assisting Advancement of Strategic Basic Technologies, "Research Relating to Press-Forming Technology for CFRP-Metal Hybrid Parts for Automobile Structural Members", and FY2014 Proceedings of the Japanese Spring Conference for the Technology of Plasticity, "Basic Studies on Reinforcing Effect of CFRP Sheet in Impact Bending Deformation in Tubular State").

[0027] However, the method of forming of the present invention has as its basic idea bonding a reinforcement with a forming material (blank material) before a forming operation so as to raise the formability of the portion with the sheet or patch bonded to it. On this point, the method of forming of the present invention basically differs from the above technique of bonding a sheet or patch of fiber reinforced plastic to a formed part after the forming operation so as to improve the mechanical properties or functionality of the formed part or reinforce it.

[0028] That fact that when forming a blank material 1, if bonding a fiber reinforced plastic sheet with a portion where breakage during forming is a concern, that is, a portion where breaking yield strength is required, the breaking yield strength is improved in a portion where breaking yield strength is required and the blank material will not break during forming is a new discovery obtained by the inventors and is the characterizing feature of the method of forming of the present invention.

[0029] FIGS. 3A and 3B show a mode in drawing high strength steel sheet where a patch of fiber reinforced plastic is bonded with a portion where breaking yield strength is required. FIG. 3A shows a mode where a patch of ring-shaped fiber reinforced plastic is bonded to a ring-shaped portion where breaking yield strength is required, while FIG. 3B shows

a cross-section of a formed part obtained by drawing the blank material shown in FIG. 3A.

[0030] In the blank material 1 shown in FIG. 3A, a reinforcement comprised of a ring-shaped fiber reinforced plastic sheet 8a is bonded so as to cover a portion where breakage during drawing is a concern, that is, a ring-shaped portion abutting against a shoulder part of the punch and requiring breaking yield strength.

[0031] As shown in FIG. 3A, when drawing high strength steel sheet, if it were possible to identify before drawing the portion where breakage during drawing is a concern, that is, the portion abutting against the shoulder part of the punch and where breaking yield strength is thus required, it would be possible to bond a sheet of fiber reinforced plastic wider than the width of the identified portion so as to completely cover the identified portion and thereby raise the breaking yield strength and improve the formability at that portion.

[0032] As shown in FIG. 3B, in the formed part 1a obtained by drawing the blank material shown in FIG. 3A, no breakage occurs at the portion with which the fiber reinforced plastic sheet 8a is bonded and where breakage during drawing is a concern, that is, the portion abutting against the shoulder part of the punch and where breaking yield strength is thus required.

[0033] FIGS. 4A and 4B show another mode when drawing high strength steel sheet where patches of fiber reinforced plastic are bonded to portions where breaking yield strength is required. FIG. 4A shows a mode where patches of ring-shaped fiber reinforced plastic are bonded to two ring-shaped portions where breaking yield strength is required, while FIG. 4B shows a cross-section of a formed part obtained by drawing the blank material shown in FIG. 4A.

[0034] In the blank material 1 shown in FIG. 4A, ring-shaped fiber reinforced plastic sheet 8b and 8c are bonded so as to cover the portions where breakage during drawing is a concern, that is, the two ring-shaped portions abutting against the shoulder parts of a punch and requiring breaking yield strength.

[0035] As shown in FIG. 4A, when drawing high strength steel sheet, even if there were a plurality of portions where breakage during drawing was a concern, that is, the portions abutting against the shoulder parts of the punch and where breaking yield strength is thus required, if it were possible to identify the positions of those portions, it would be possible to bond a sheet of fiber reinforced plastic so as to completely cover the identified portions and thereby raise the breaking yield strength and improve the formability at those identified plurality of portions.

[0036] As shown in FIG. 4B, in the formed part 1b obtained by drawing the blank material shown in FIG. 4A, no breakage occurs at the portions to which the fiber reinforced plastic sheets 8b and 8c are bonded and where breakage during drawing is a concern, that is, two ring-shaped portions abutting against the shoulder parts of the punch and where breaking yield strength is thus required.

[0037] FIGS. 3A and 3B and FIGS. 4A and 4B show the case of drawing a circular blank material axially symmetrically, but the blank material is not limited to a circular blank material. Further, the drawing operation is not limited to drawing axially symmetrically.

[0038] According to the method of forming of the present invention, the breaking yield strength of a portion where breaking yield strength is required (a portion where breakage is a concern) is improved, so the freedom of shape of the blank material, freedom of the forming mode, and freedom of shape of the formed part are greatly expanded.

[0039] In the method of forming of the present invention, when drawing a blank material, if it were possible to identify a portion where breakage is a concern, that is, a portion abutting against a shoulder part of a punch and where breaking yield strength is required, it would be possible to bond a reinforcement so as to cover the identified portion and raise the breaking yield strength and prevent breakage at the above identified portion.

[0040] FIGS. 3A and 3B and FIGS. 4A and 4B show the states when bonding reinforcements comprised of ring-shaped sheets of fiber reinforced plastic to portions where breaking yield strength is required. The shape of the reinforcement is not limited to a specific shape and may be suitably set in accordance with the shape, position, etc. of the identified portion where breaking yield strength is required.

[0041] FIGS. 3A and 3B and FIGS. 4A and 4B show modes of bonding ring-shaped sheets of fiber reinforced plastic to the outsides of portions where breaking yield strength is required, but the locations of bonding the reinforcement are not limited to the outsides of the portions where breaking yield strength is required. They may be any of the inside, outside, and two sides of the portion where breaking yield strength is required. The locations of bonding the reinforcement may be suitably set according to the shapes, positions, etc. of the portions where breaking yield strength is required.

[0042] Furthermore, when bonding a reinforcement to a portion where breaking yield strength is required, it may also be bonded divided into suitable sections.

[0043] FIG. 5 shows a mode of bonding a reinforcement comprised of divided sections of ring-shaped fiber reinforced plastic to a ring-shaped portion where breaking yield strength is required. In FIG. 5, the ring-shaped fiber reinforced plastic is divided into four sections. The sections of fiber reinforced plastic 8a' are bonded arranged in a ring shape.

[0044] When joining a divided reinforcement, the mode of division may be suitably determined according to the shape, position, etc. of the portion where the specified breaking yield strength is required.

[0045] Above, the method of forming of the present invention was explained with reference to the example of a drawing operation. The method of forming of the present invention is not however limited to a drawing operation. It may also be applied to various forming operations such as shown in FIGS. 6 to 9. FIGS. 6 to 9 show portions where breakage is a

concern in various forming operations. FIG. 6 shows deep drawing, FIG. 7 shows stretch flanging, FIG. 8 shows bending, and FIG. 9 shows stretch forming. If such general forming operations, a portion where breakage is a concern can be predicted relatively easily.

[0046] Specifically, when deep drawing, the portion where breakage is a concern is the punch shoulder 61, with stretch flanging, it is the flange end 71, with bending, it is the bent portion 81, and with stretch forming, it is the punch stretching portions 91. Therefore, before forming the metal sheet, it is sufficient to bond a reinforcement and then performing forming so as to cover a position forming that portion at the time of forming.

[0047] When forming a metal sheet of a complicated shape where a portion where breaking yield strength is required would be difficult to predict, as shown in FIG. 10, CAE (computer aided engineering) may be used to predict a portion where thickness would be reduced if not using a reinforcement and where breakage is thus a concern and then forming in the case of bonding a reinforcement at that portion where breakage is a concern may be again analyzed by CAE so as to determine the position for bonding the reinforcement.

[0048] The reinforcement is not particularly limited in grade so long as one able to bear the stress applied to the portion where breakage during forming is a concern. If considering the strength and ease of handling, a sheet of fiber reinforced plastic or high strength steel foil is preferably used. The fiber reinforced plastic need only be a plastic reinforced by a fiber. It is not limited to any specific fiber or plastic. As a suitable example, carbon fiber reinforced plastic may be mentioned. As high strength steel foil, steel foil having a tensile strength at ordinary temperature of 600 MPa or more can be illustrated.

[0049] When using a reinforcement comprised of fiber reinforced plastic, the fiber reinforced plastic is preferably bonded so that the direction of the fibers runs along the direction in which breaking yield strength is required, specifically, cuts across any crack formed.

[0050] The reinforcement is designed to improve the breaking yield strength at the portion where breaking yield strength is required, so a required thickness is necessary, but the material is not limited to a specific thickness. The thickness of the reinforcement may be suitably set considering the grade of the blank material, the mode of drawing, the shape of the formed part, etc.

[0051] The formed part obtained by forming a blank material with a reinforcement bonded to the portion where breaking yield strength is required may, depending on the application, be used after removing the reinforcement or may be used with the reinforcement remaining bonded as it is.

[0052] For this reason, the bonding strength when bonding a reinforcement with a portion where breaking yield strength is required may be suitably selected in accordance with the application of the formed part.

[0053] The method of bonding the reinforcement with a portion where breaking yield strength is required is not particularly limited. When the reinforcement is fiber reinforced plastic, an adhesive or resin is preferably used. The types of the adhesive and resin are not particularly limited. It is also possible to consider whether to remove the reinforcement from the formed part or leave it as it is so as to suitably select the adhesive. If the reinforcement is high strength steel foil and the reinforcement does not have to be removed from the formed part, it may be bonded by diffusion bonding.

[0054] Here, the mechanism by which bonding of a reinforcement improves the breaking yield strength and improves the formability will be explained.

[0055] In general, when drawing a blank material by a die and a punch, the breaking yield strength P_{break} of the blank material abutting against a shoulder part of the punch can be calculated by the following formula (1) (see Plastic Forming Technology Series 13 "Press Drawing - Process Design and Die Design -" (Corona), page 23):

$$P_{break} = 2\pi R t_0 F \{ 2(r+1)(r+2)/3(2r+1) \}^{(n+1)/2} (n/e)^n \dots (1)$$

where,

R: radius of punch

t_0 : thickness of blank material

r: Lankford value

e: Napier's constant (base of natural logarithm)

F, n: parameters of Swift formula

[0056] The breaking yield strength P'_{break} of the blank material when reinforcing by a reinforcement a portion of the blank material where breakage is a concern (portion where breakage during drawing is a concern), that is, a portion abutting against a shoulder part of the punch and where breaking yield strength is thus required, can be calculated by the following formula (2)

$$P'_{break} = P_{break} + 2\pi R t_{frp} TS_{frp} \dots (2)$$

P'break: breaking yield strength of blank material abutting against shoulder part of punch

R: radius of punch

t_{frp}: thickness of reinforcement

TS_{frp}: tensile strength of reinforcement

[0057] As shown in the above formula (2), if bonding a sheet or patch of fiber reinforced plastic as a reinforcement with a portion of the blank material where breakage is a concern, the breaking yield strength P'break after bonding will exceed the breaking yield strength Pbreak of the blank material, so it is possible to estimate the improvement in formability at the above portion where breakage is a concern. In this way, the method of forming of the present invention can be theoretically verified.

[0058] The method of forming of the present invention exhibits its effect without regard to the worked material, that is, the metal sheet, and the content of the forming operation. In particular, it exhibits a large effect in forming high strength steel sheet with a tensile strength of 590 MPa or more - which tends to become low in formability.

Examples

[0059] Next, an example of the present invention will be explained, but the conditions in the example are an illustration of the conditions employed for confirming the workability and effect of the present invention. The present invention is not limited to this illustration of conditions. The present invention can employ various conditions so long as not deviating from the gist of the present invention and achieving the object of the present invention.

Example

[0060] As shown in FIG. 11, on a thickness 1.0 mm, diameter 108 mm blank material (dual phase steel) 112, a thickness 0.7 mm, diameter 58 mm adhesive sheet (polypropylene resin sheet) 113 and thickness 0.23 mm, diameter 58 mm sheet of carbon fiber reinforced plastic 111 were stacked in that order. The assembly was heated by a hot crimping machine 114 at 180°C for 1 minute, then pressed at 0.049 MPa (≈ 5 tonf/m²) for 1 minute and air-cooled to bond the carbon fiber reinforced plastic 111 with the blank material 112.

[0061] The blank material 112 with the carbon fiber reinforced plastic 111 bonded to it was drawn using the punch and die used in the comparative example.

Comparative Example

[0062] A thickness 1.0 mm, diameter 108 mm blank material (dual phase steel) was drawn using the following punch and die: Punch shoulder: R5

Punch diameter: 50 mm

Die shoulder: R5

Die diameter: 60 mm

Blank holder pressure: 0.098 MPa (≈ 10 tonf/m²)

[0063] The results are shown in FIG. 12. (a) shows the results of a comparative example of drawing a portion where breaking yield strength is required to which a sheet of fiber reinforced plastic is not bonded, while (b) shows the results of an example of drawing a portion where breaking yield strength is required to which a sheet of fiber reinforced plastic is bonded.

Industrial Applicability

[0064] According to the present invention, when forming a metal sheet, it is possible to raise the breaking yield strength of a portion where breaking yield strength is required, improve the formability of the metal sheet, and prevent breakage during forming without changing the material of the metal sheet and the forming process. The present invention exhibits its effect regardless of the worked material, that is, the metal sheet, and the content of the forming operation. In particular, it exhibits a great effect for operations on high strength steel sheet where the formability tends to become low like drawing, stretch forming, stretch flanging, and bending. The present invention has high applicability in industries manufacturing

metal products.

Reference Signs List

- 5 **[0065]**
- 1. blank material
 - 1'. flange part
 - 1a, 1b. formed part
 - 10 2. die
 - 3. punch
 - 3'. shoulder part
 - 4. blank holder
 - 5. breakage
 - 15 6. deformation resistance
 - 7. portion where breaking yield strength is required
 - 8. sheet of fiber reinforced plastic
 - 8a, 8a'. reinforcement of fiber reinforced plastic
 - 8b, 8c. reinforcement of fiber reinforced plastic
 - 20 61. punch shoulder
 - 71. flange end
 - 81. bent portion
 - 91. punch stretching portion
 - 111. sheet of carbon fiber reinforced plastic
 - 25 112. blank material
 - 113. adhesive sheet
 - 114. hot crimping machine

30 **Claims**

- 1. A method of forming a metal sheet comprising the steps of bonding a reinforcement to a part of the metal sheet and then forming the metal sheet.
- 35 2. The method of forming a metal sheet according to claim 1, wherein the reinforcement is bonded with a portion of the metal sheet reduced in thickness in the forming process.
- 3. The method of forming a metal sheet according to claim 1 or 2, wherein the metal sheet is a high strength steel sheet having a tensile strength of 590 MPa or more.
- 40 4. The method of forming a metal sheet according to any one of claims 1 to 3, wherein the reinforcement is a fiber reinforced plastic.
- 5. The method of forming a metal sheet according to claim 4, wherein the fiber reinforced plastic is bonded so that the direction of the fibers runs along the direction in which the breaking strength of the metal sheet is required.
- 45 6. The method of forming a metal sheet according to any one of claims 1 to 3, wherein the reinforcement is a high strength steel foil.
- 50 7. A formed part drawn by the method of forming a high strength steel sheet according to any one of claims 1 to 6.

55

FIG. 1

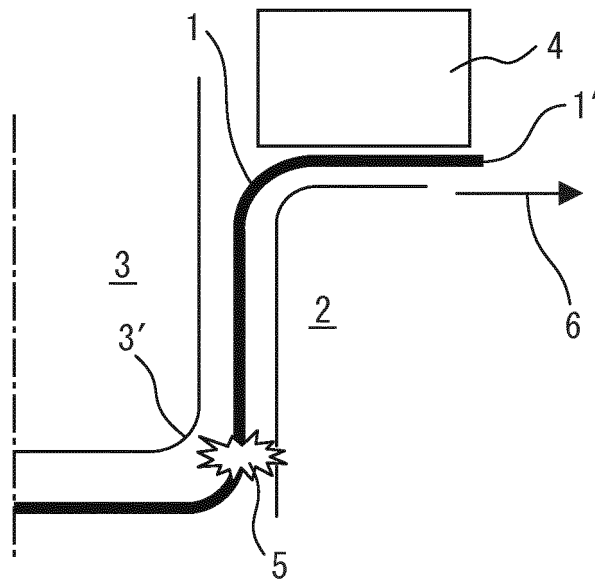


FIG. 2

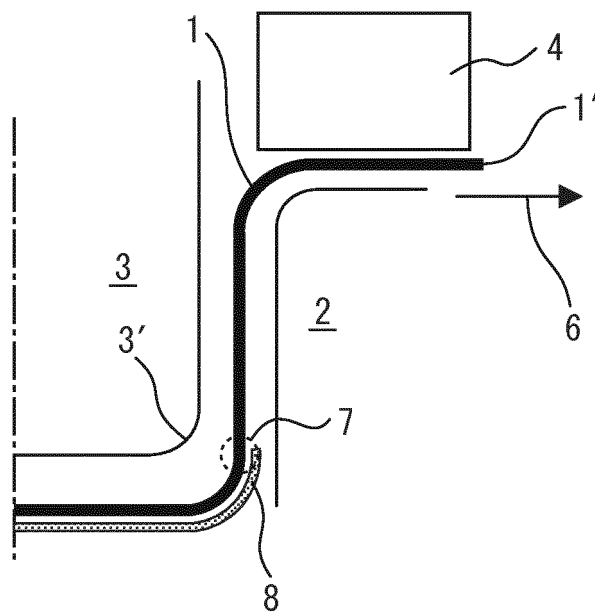


FIG. 3

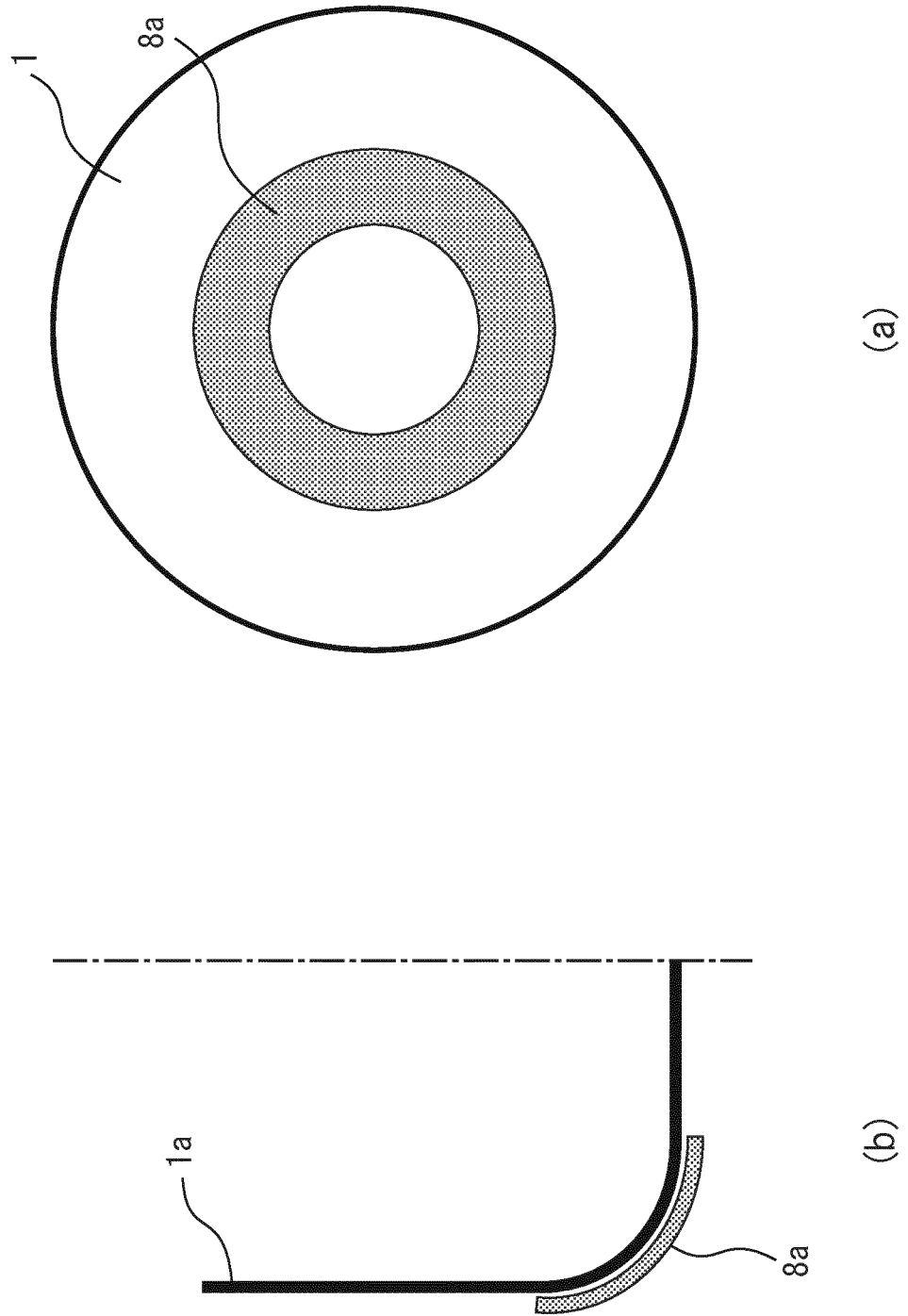


FIG. 4

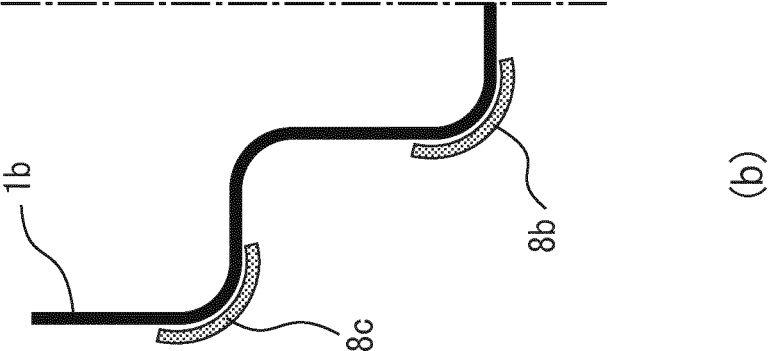
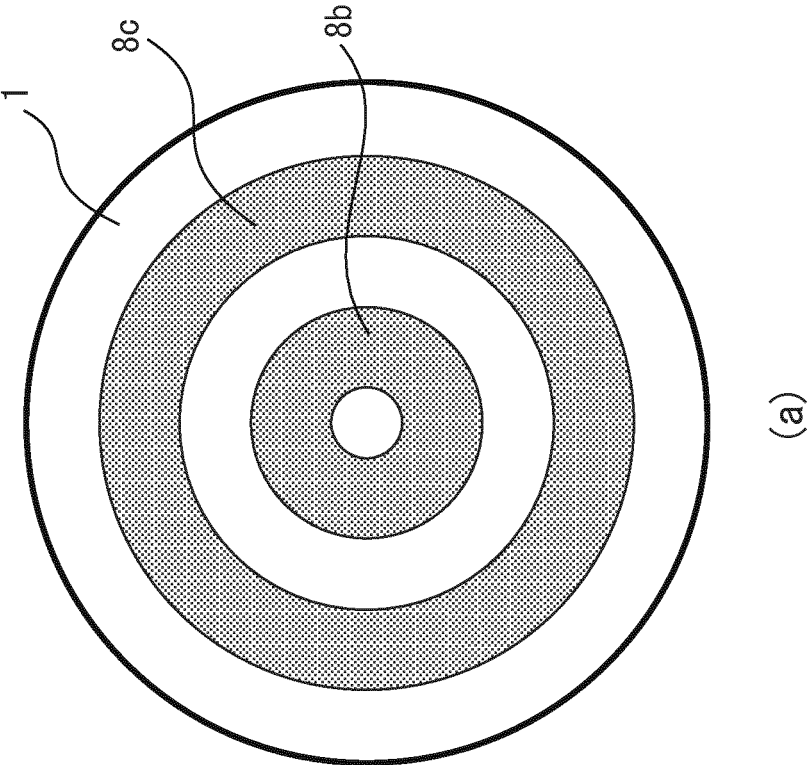


FIG. 5

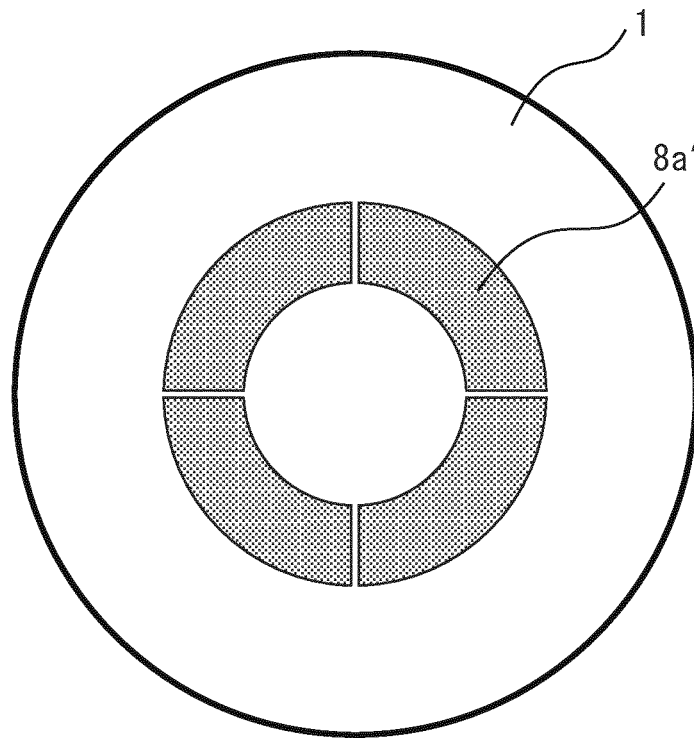


FIG. 6

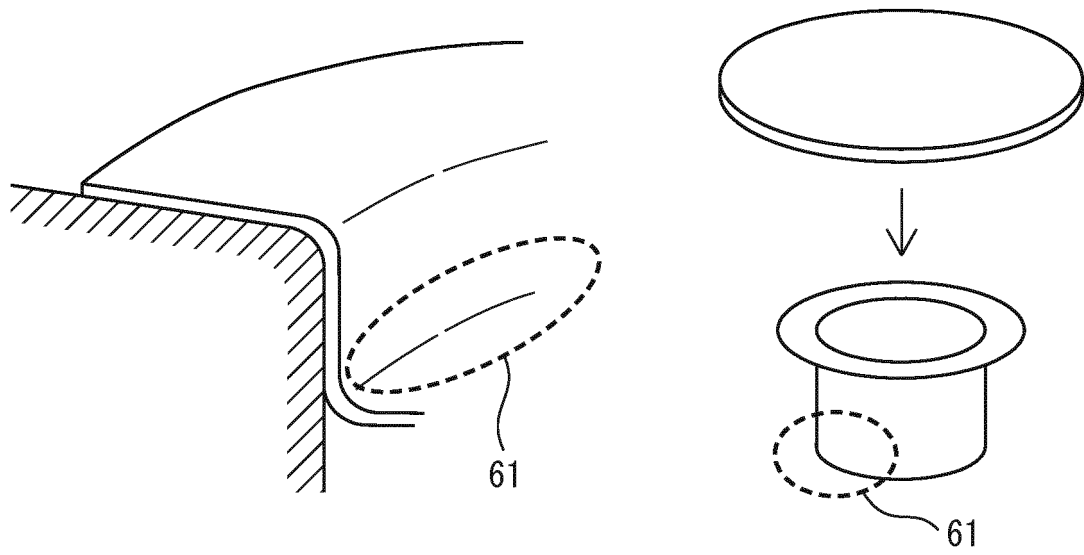


FIG. 7

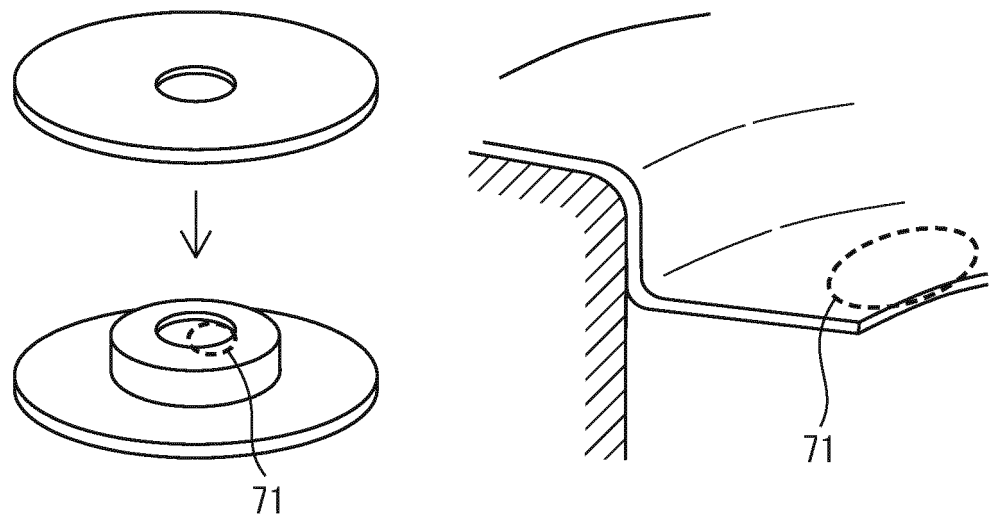


FIG. 8

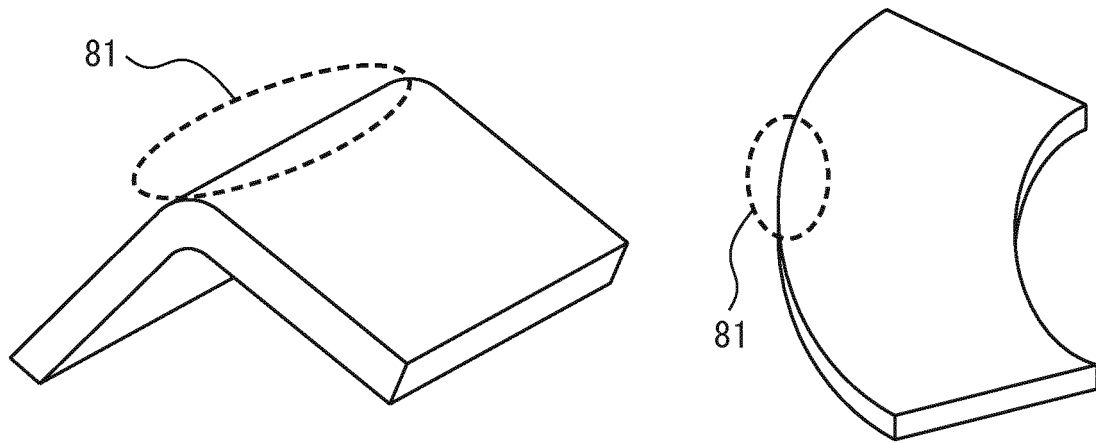


FIG. 9

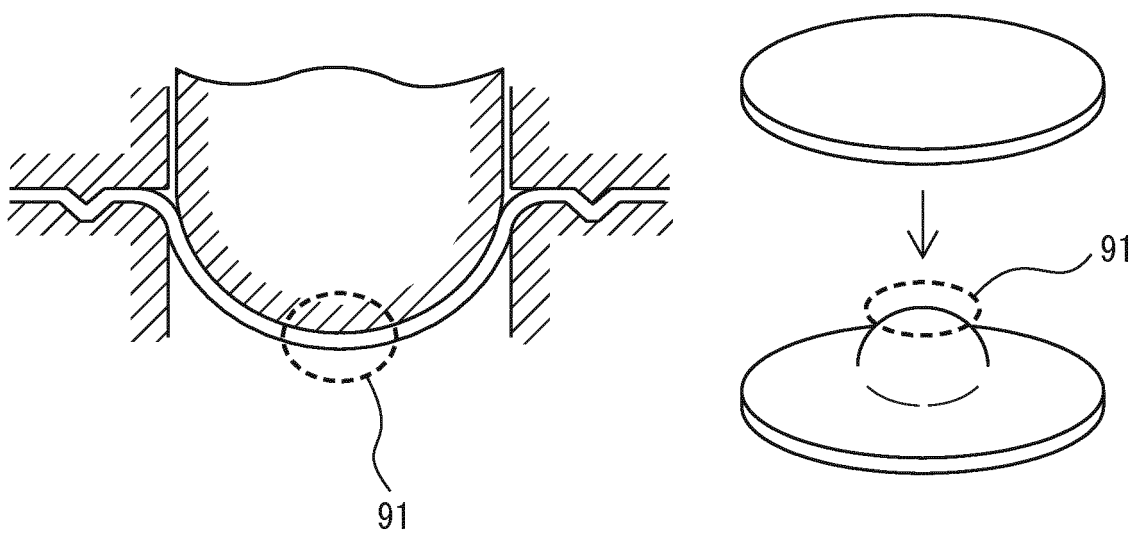


FIG. 10

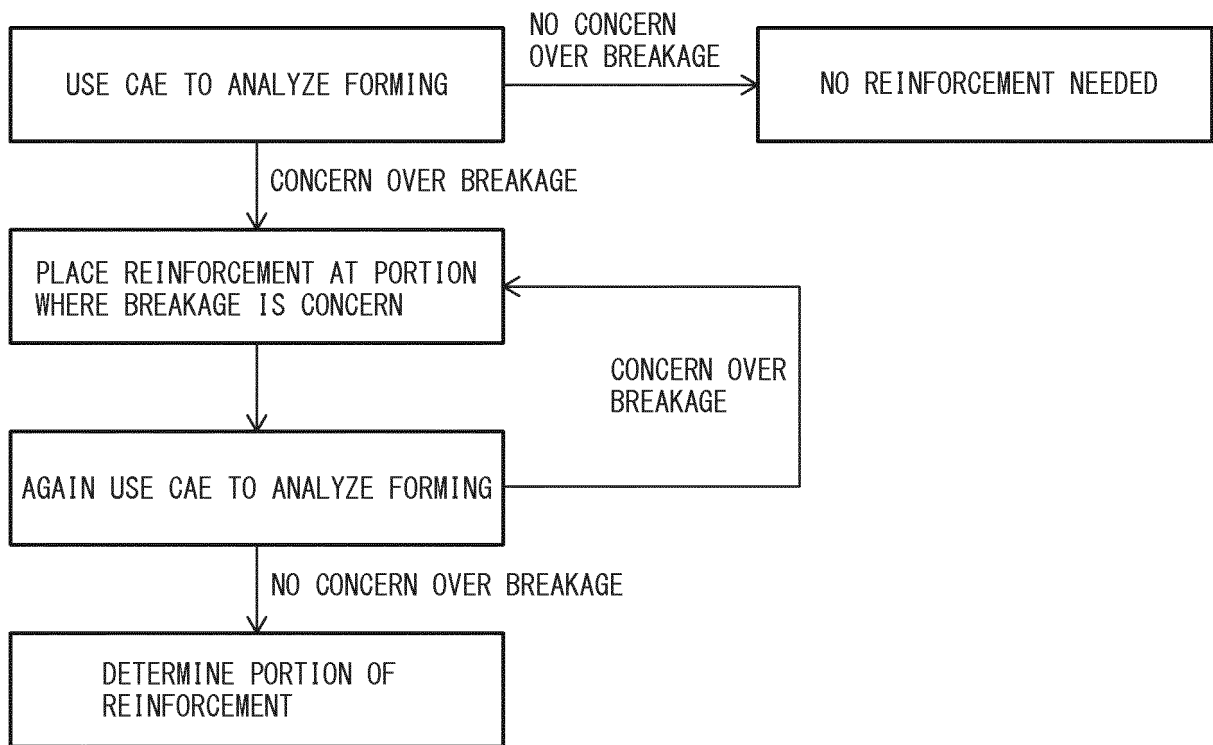


FIG. 11

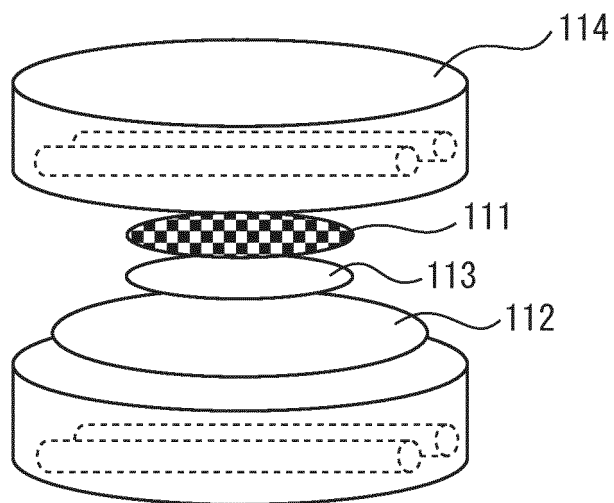
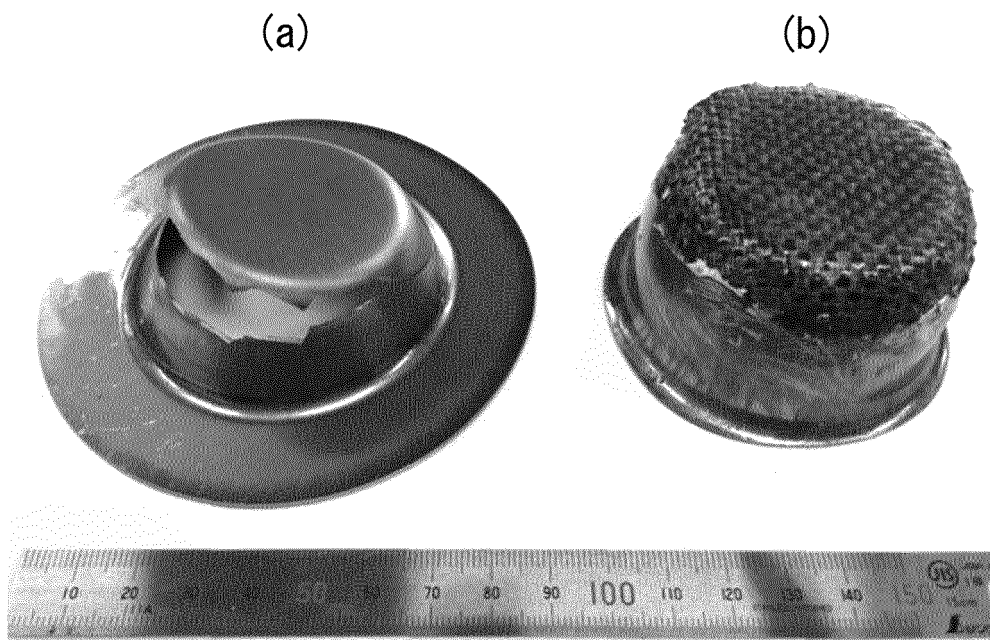


FIG. 12



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/054936

A. CLASSIFICATION OF SUBJECT MATTER

B21D22/20(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)

B21D22/20

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

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.
X Y	WO 2012/36262 A1 (Sumitomo Metal Industries, Ltd.), 22 March 2012 (22.03.2012), paragraphs [0025] to [0026], [0035] to [0036], [0081] to [0086], [0090], [0102]; fig. 2, 8 to 9 & US 2014/0147693 A1 paragraphs [0070] to [0072], [0082] to [0084], [0147] to [0154], [0158], [0174]; fig. 2, 8 to 9 & EP 2617509 A1 & KR 10-2013-0055016 A & CN 103228392 A	1-3, 6-7 4-5

☒ Further documents are listed in the continuation of Box C.
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16 March 2016 (16.03.16)Date of mailing of the international search report
29 March 2016 (29.03.16)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2007-276295 A (Mazda Motor Corp.), 25 October 2007 (25.10.2007), paragraphs [0006] to [0010], [0017] to [0019]; fig. 1 to 3, 7, 8 (Family: none)	4-5

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 10175024A B [0009]
- JP 4532709 B [0009]