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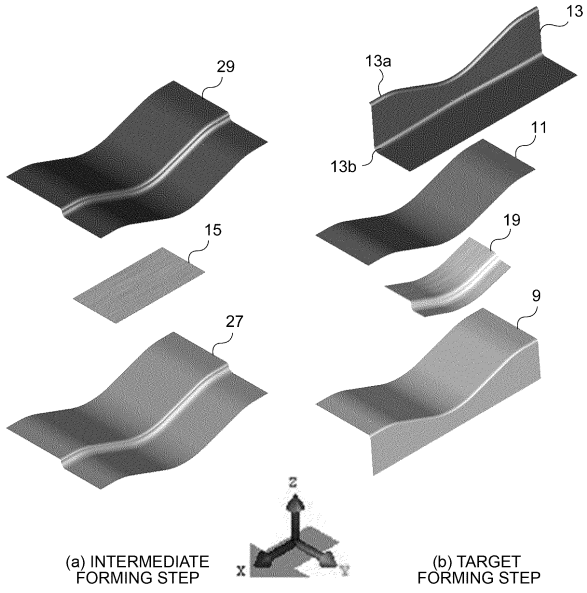
(54) METHOD FOR MANUFACTURING PRESS-MOLDED ARTICLE

(57) A method of manufacturing a press-formed part 1 including at least a top portion 3 having a concave curved portion in a side view and a side wall portion 7 continuous from the top portion 3 via a punch shoulder R portion 5 according to the present invention includes: a first forming step of press-forming an intermediate forming part 19 including an intermediate top portion 21 curved in the same direction as the top portion 3, a step-shaped portion 17 formed of a step which is continuous with a ridge line portion 23 formed at a portion corresponding to the punch shoulder R portion 5, and an outer surface portion 25 that extends outward continuously from the step-shaped portion 17 and curves in the same direction as the intermediate top portion 21; and a second forming step of press-forming the intermediate forming part 19 into the press-formed part 1.

FIG.1



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Description

Field

[0001] The present invention relates to a method of manufacturing a press-formed part including at least a top portion having a concave curved portion that curves concavely in a side view and a side wall portion continuous from the top portion via a punch shoulder R portion. In the present specification, for example, the term "punch shoulder R portion" refers to a portion of a formed part, and the term "punch shoulder" refers to a portion of a mold.

Background

[0002] While the vehicle body collision safety is being improved due to the tightening of the vehicle collision safety standards, it is also necessary to reduce the weight of the vehicle body for improvement in fuel consumption and electrification of vehicles due to the carbon dioxide emission control. In order to achieve both the improvement in collision safety and reduction in weight of vehicle bodies, application of high-strength steel sheet (also referred to as high-tensile steel sheet) having a tensile strength of 590 MPa or more to structural parts of vehicle bodies is in progress.

[0003] Examples of vehicle parts or partial structures thereof include a press-formed part having at least a top portion and a side wall portion continuous from the top portion via a punch shoulder R portion, in which the top portion has a curved portion that curves concavely in a side view. When such a press-formed part is press-formed, the distal end portion of the side wall portion continuous with the punch shoulder R portion at the bottom of the concave curved portion of the top portion and in the vicinity of the bottom undergo stretch flange deformation. Therefore, the sheet thickness is reduced at the portion, and cracking is likely to occur. In addition, the sheet thickness of the punch shoulder R portion at the bottom of the concave curved portion of the top portion and in the vicinity of the bottom increases, and buckling (wrinkles, folds) is likely to occur.

[0004] In particular, in the case of a high-tensile steel sheet, cracking of the portion having undergone the stretch flange deformation and buckling (wrinkles, folds) of the punch shoulder R portion are likely to occur due to the increase in strength, which is particularly a problem.

[0005] In this regard, Patent Literature 1, for example, conventionally proposes a countermeasure against cracking due to stretch flange deformation of a press-formed part including a flat top portion having a concave outer peripheral edge in a top view and a side wall portion continuous from the top portion along the concave outer peripheral edge.

Citation List

Patent Literature

[0006] Patent Literature 1: WO 2014/097745 A

Summary

Technical Problem

[0007] The press-forming method described in Patent Literature 1 is targeted to a press-formed part in which the top portion is flat and has a concave outer peripheral edge in a top view. On the other hand, the present invention is targeted to a press-formed part including at least a top portion having a concave curved portion that curves concavely in a side view and a side wall portion continuous from the top portion via a punch shoulder R portion. As described above, the press-formed part targeted by Patent Literature 1 and the press-formed part targeted by the present invention have different shapes.

[0008] Therefore, even if the press-forming method of Patent Literature 1 is applied to the press-formed part targeted by the invention of the present application, it is not possible to prevent cracking of a portion of the press-formed part having undergone the stretch flange deformation, or wrinkles and folds at the punch shoulder R portion.

[0009] The present invention has been made in view of the above problems, and an object of the present invention is to provide a method of manufacturing a press-formed part including at least a top portion having a concave curved portion that curves concavely in a side view and a side wall portion continuous from the top portion via a punch shoulder R portion, the method capable of suppressing cracking of the press-formed part, or preventing wrinkles and folds.

Solution to Problem

[0010] To solve the problem and achieve the object, (1) a method of manufacturing a press-formed part according to the present invention is the method of manufacturing the press-formed part including at least a top portion having a concave

curved portion that curves concavely in a side view and a side wall portion continuous from the top portion via a punch shoulder R portion. The method includes: a first forming step of press-forming an intermediate forming part including an intermediate top portion curved in the same direction as the top portion, a step-shaped portion formed of a step which is continuous with a ridge line portion formed at a portion corresponding to the punch shoulder R portion, and an outer surface portion that extends outward continuously from the step-shaped portion and curves in the same direction as the intermediate top portion; and a second forming step of press-forming the intermediate forming part into the press-formed part.

[0011] (2) Moreover, in the method of manufacturing the press-formed part according to above (1), a radius of curvature of the ridge line portion of the intermediate forming part may be greater than or equal to a radius of curvature of the punch shoulder R portion of the press-formed part.

Advantageous Effects of Invention

[0012] The method of manufacturing a press-formed part according to the present invention has an effect of preventing wrinkles and folds in the punch shoulder R portion and the vicinity thereof at the bottom of the concave curved portion of the top portion and in the vicinity of the bottom, and suppressing cracking in the distal end portion of the side wall portion continuous with the punch shoulder R portion.

Brief Description of Drawings

[0013]

FIG. 1 is an explanatory view concerning a method of manufacturing a press-formed part according to an embodiment.
FIG. 2 is an explanatory view of an intermediate forming part formed according to the present embodiment.
FIG. 3 is an explanatory diagram concerning a forming process in a second forming step according to the present embodiment.
FIG. 4 is an explanatory diagram concerning functions and effects according to the present embodiment.
FIG. 5 is an explanatory view concerning a method of manufacturing a press-formed part according to another aspect of the present invention.
FIG. 6 is an explanatory view of a press-formed part to be manufactured in Examples.
FIG. 7 is an explanatory view of a press-formed part targeted by the present invention.
FIG. 8 is an explanatory view concerning a conventional method of manufacturing a press-formed part.
FIG. 9 is an explanatory diagram concerning a forming process in the conventional press-forming method.
FIG. 10 is an explanatory diagram concerning a problem of a press-formed part manufactured by the conventional press-forming method.

Description of Embodiments

[0014] Hereinafter, an embodiment of a method of manufacturing a press-formed part according to the present invention will be described. Note that the present invention is not limited by the present embodiment.

[0015] An example of a press-formed part of a target shape targeted by the present invention will be described with reference to FIG. 7. The press-formed part 1 targeted by the present invention includes at least a top portion 3 having a concave curved portion that curves concavely in a side view, and a side wall portion 7 continuous from the top portion 3 via a punch shoulder R portion 5, and an example thereof is an article having an L-shaped cross section as illustrated in FIG. 7.

[0016] A problem that occurs when the press-formed part 1 is press-formed will be described with reference to a case where a steel sheet having a sheet thickness of 1.4 mm and a tensile strength of 980 MPa class is press-formed as a blank. FIG. 8 illustrates a conventional mold used when the press-formed part 1 targeted by the present invention is press-formed by one step. The conventional mold includes a punch 9 having a concave curved portion, a pad 11 having a concave curved portion similar to that of the punch 9, and a die 13. While the blank 15 being a metal sheet is pressed by the pad 11 and the punch 9 so that the concave curved portion of the top portion 3 is formed, the die 13 is relatively moved to form the side wall portion 7.

[0017] The conventional press forming process will be described with reference to FIG. 9. FIG. 9 illustrates a cross section (a cross section cut in the direction of arrow A illustrated in FIG. 7) of the bottom of the curve in the concave curved portion of the top portion 3 of the press-formed part 1 during the press forming. Note that a numerical value such as [28mmup] in FIG. 9 represents a gap in the press forming direction between a punch shoulder 33 of the punch 9 and a die jaw portion 13a (see FIG. 8 and [2mmup] of FIG. 9) up to the bottom dead center, in which the sheet thickness is taken into account. For example, the gap between the punch shoulder 33 of the punch 9 and the die jaw portion 13a at [28mmup] is obtained by adding 28 mm to the sheet thickness of the press-formed part 1.

[0018] As illustrated in FIG. 9, the blank 15 is pressed against the punch 9 by the pad 11 at [47mmup], and a concave curved portion is formed. In this state, the entire blank 15 including the portion to be formed into the side wall is curved in a concave shape in the direction perpendicular to the drawing plane.

[0019] At [35mmup], a die shoulder 13b comes into contact with the blank 15 so that the side wall portion 7 starts to be formed. Therefore, the end of the portion corresponding to the side wall of the blank 15 is curved downward. When the side wall portion 7 starts to be formed, the portion corresponding to the side wall is curved in a concave shape in the direction perpendicular to the drawing plane and thus has high rigidity, and is less likely to be deformed along the punch shoulder R portion 5 (ridge line) serving as a boundary between the top portion 3 and the side wall portion 7. Therefore, at [28mmup], the bottom of the concave curved portion of the blank 15 brought into contact with the die shoulder 13b of the die 13 is bent, and a buckled fold is generated. Furthermore, the portion where the buckled fold is generated is bent in the forming direction up to [19mmup] without coming into contact with the punch shoulder 33 of the punch 9. At [8mmup] and [2mmup], the portion where the buckled fold is generated is formed into the side wall portion 7 by the gap between the die 13 and the punch 9, and becomes the punch shoulder R portion 5 by coming into contact with the punch shoulder 33 of the punch 9 at the bottom dead center.

[0020] FIG. 10 is a diagram illustrating a sheet thickness distribution at the bottom dead center obtained by subjecting a conventional press forming process to FEM analysis. The dotted line A-A in FIG. 10 indicates the position of the bottom of the concave curved portion similarly to FIG. 7. As illustrated in FIG. 10, the distal end portion of the side wall portion 7 continuous with the bottom of the concave curved portion having undergone stretch flange deformation exhibits a maximum sheet thickness decrease rate of as large as 12.3%, so that cracking is likely to occur. On the other hand, the punch shoulder R portion 5 exhibits a maximum sheet thickness increase rate of as large as 10.0%, and hence a wrinkle or fold is likely to be generated.

[0021] In the conventional press forming process, the curved portion having a concave shape in a side view formed at an initial stage of press forming has high rigidity due to its shape. Therefore, when the side wall portion 7 is to be subsequently formed by the die 13, a large compressive force acts on the blank 15 to increase the sheet thickness, so that a buckled fold is generated and hence a wrinkle or fold is likely to be generated. In addition, since the top portion 3 curves concavely, the side wall portion 7 continuous with the concave curved portion expands to the left and right of the concave curved portion and undergoes stretch flange deformation, and a large tension acts on the distal end of the side wall portion 7 continuous with the bottom of the curve, so that the sheet thickness decreases and cracking is likely to occur.

[0022] In the study for suppressing the sheet thickness increase and the sheet thickness decrease in such a series of forming processes, the present inventor has focused on the deformation of the blank 15 from [28mmup] to [2mmup] in FIG. 9. That is, the present inventor has considered that if the blank 15 can be brought into contact with the punch shoulder 33 of the punch 9 at the initial stage of forming at [28mmup], the blank 15 will not suffer from a buckled fold in the forming direction without coming into contact with the punch shoulder 33 of the punch 9, and wrinkles and folds as in the conventional art can be prevented. Furthermore, the present inventor has considered that if the forming height of the side wall portion 7 at the time of forming the side wall portion 7 of the target shape can be reduced, the degree of stretch flange deformation is reduced and hence cracking is less likely to occur.

[0023] Therefore, in the present invention, the press forming step is divided into two steps of a first forming step and a second forming step, as illustrated in FIG. 1. In the first forming step, an intermediate forming part 19 curved in the same direction as a press-formed part 1 and having a step-shaped portion 17 is press-formed, and in the second forming step, the intermediate forming part 19 is press-formed into the press-formed part 1 of a target shape. The intermediate forming part 19 includes an intermediate top portion 21 curved in the same direction as the top portion 3 of the press-formed part 1, a ridge line portion 23 formed at a portion corresponding to a punch shoulder R portion 5, and the step-shaped portion 17 formed of a step which is continuous with the ridge line portion 23. FIG. 2 illustrates an example in which the intermediate top portion 21 having the same shape as the top portion 3 of the press-formed part 1 is provided. In addition, an outer surface portion 25 which extends outward continuously with the step-shaped portion 17 and is curved in the same direction as the intermediate top portion 21 is provided. The outer surface portion 25 is formed into a side wall portion 7 in the second forming step. FIG. 2 illustrates an example in which the outer surface portion 25 is parallel to the intermediate top portion 21, but in the present invention, the outer surface portion 25 only needs to be curved in the same direction as the intermediate top portion 21, and does not need to have the same curvature as the intermediate top portion 21. In addition, the intermediate top portion 21 only needs to reach a curvature of the top portion 3 of the press-formed part 1 in the second forming step, and thus does not need to completely match the shape of the top portion 3 of the press-formed part 1 of the target shape. Hereinafter, the first forming step and the second forming step will be described in detail with reference to FIG. 1, taking the case where the intermediate forming part 19 has the shape illustrated in FIG. 2 as an example.

<First forming step>

[0024] In the first forming step, a step-forming punch 27 and a step-forming die 29 are used, as illustrated in FIG. 1(a). The intermediate forming part 19 having the intermediate top portion 21, the step-shaped portion 17, and the outer surface

portion 25 is press-formed by the step-forming punch 27 and the step-forming die 29. The radius of curvature of the ridge line portion 23 of the intermediate forming part 19 is preferably greater than or equal to the radius of curvature of the punch shoulder R portion 5 of the press-formed part 1. The upper limit of the radius of curvature of the ridge line portion 23 is not particularly limited, but it is preferably up to 5 times the radius of curvature of the punch shoulder R portion 5 of the press-formed part 1 in accordance with the shape of the press-formed part 1 and the thickness of the metal sheet. This is because it allows the ridge line portion 23 to easily come into contact with the punch shoulder 33 of the punch 9 in the second forming step.

<Second forming step>

[0025] In the second forming step, the punch 9, the pad 11, and the die 13 for forming the press-formed part 1 of a target shape are used, as illustrated in FIG. 1(b). The tools illustrated in FIG. 1(b) is similar to those illustrated in FIG. 8 as a conventional example. The intermediate forming part 19 is placed on the punch 9 and pressed by the pad 11, and the die 13 is relatively moved toward the punch 9 to form the outer surface portion 25 into the side wall portion 7, thereby forming the press-formed part 1 of a target shape.

[0026] FIG. 3 illustrates movements of the punch 9 and the die 13 in the second forming step and a deformation process of the intermediate forming part 19 in a cross section cut in the direction of the arrow A illustrated in FIG. 2. Note that a numerical value such as [28mmup] represents a gap in the press forming direction between the punch shoulder 33 and the die jaw portion 13a up to the bottom dead center, in which the sheet thickness is taken into account, similarly to the case of FIG. 9 described above. Therefore, the gap between the punch shoulder 33 and the die jaw portion 13a at [28mmup] is obtained by adding 28 mm to the sheet thickness of the press-formed part 1.

[0027] As illustrated in FIG. 3, the intermediate forming part 19 is placed on the punch 9 and pressed by the pad 11 in the second forming step. At this time, the ridge line portion 23 of the step-shaped portion 17 comes into contact with the punch shoulder 33 of the punch 9, as illustrated in the drawing of [47mmup]. Since the step-shaped portion 17 of the intermediate forming part 19 is along the punch shoulder 33 in this manner, the degree of deformation of the ridge line portion 23 in the subsequent forming processes is reduced, thereby suppressing the increase in the sheet thickness and thus preventing a buckled fold.

[0028] Subsequently, the die 13 relatively moves toward the punch 9 and then both end portions of the die 13 in the longitudinal direction come into contact with both end portions of the outer surface portion 25 of the intermediate forming part 19 at [35mmup], whereby the end portion of the outer surface portion 25 of the intermediate forming part 19 slightly rises.

[0029] Furthermore, when the forming proceeds from [28mmup] to [19mmup], the die shoulder 13b of the die 13 comes into contact with the bottom of the concave curved portion of the outer surface portion 25, and the entire outer surface portion 25 is bent back. The forming of the side wall portion 7 further proceeds through [8mmup] and [2mmup], and the forming is completed at the bottom dead center.

[0030] Since the step-shaped portion 17 is formed in the intermediate forming part 19, the forming height of the side wall portion in the second forming step in the forming process of the side wall portion 7 corresponds to the distance from the lower portion of the step-shaped portion 17 to the end portion of the outer surface portion 25. Therefore, the forming height of the side wall portion in the second forming step is shorter than the distance from the R start position of the ridge line portion 23 of the top portion 3 to the end portion of the blank 15 as in the conventional example. Therefore, a decrease in sheet thickness due to stretch flange deformation is suppressed, and occurrence of cracking can be prevented.

[0031] FIG. 4 is a diagram illustrating the sheet thickness distribution at the bottom dead center in the first forming step and the second forming step obtained by subjecting the press forming process of the present embodiment to FEM analysis. FIG. 4(a) illustrates the sheet thickness distribution at the bottom dead center in the first forming step. FIG. 4(b) illustrates the sheet thickness distribution at the bottom dead center in the second forming step. In the first forming step, the maximum sheet thickness increase rate was 3.1% at the ridge line portion 23, and the maximum sheet thickness decrease rate was 3.7% at the outer surface portion 25, as described in FIG. 4(a). In the second forming step, the maximum sheet thickness increase rate was 3.1% at the punch shoulder R portion 5, and the maximum sheet thickness decrease rate was 10.8% at the distal end portion of the side wall portion 7, as described in FIG. 4(b).

[0032] In comparison between FIG. 4(b) of the present embodiment and FIG. 10 of the conventional example, the maximum sheet thickness increase rate at the punch shoulder R portion 5 (ridge line portion 23) was significantly reduced to 3.1% in the present embodiment from 10.0% of the conventional example. Therefore, it can be seen that wrinkles and folds at the ridge line portion 23 can be prevented. Furthermore, the maximum sheet thickness decrease rate at the distal end portion of the side wall portion 7 was reduced to 10.8% in the present embodiment from 12.3% of the conventional example. Therefore, it can be seen that cracking caused by stretch flange deformation can be suppressed.

[0033] According to the above description, the die 13 used in the second forming step had the linear die shoulder 13b for forming the side wall portion 7, as illustrated in FIG. 1(b). However, the die used in the second forming step in the present invention may be a die 31 having a die shoulder 31b curved along the outer surface portion 25 of the intermediate forming

part 19, as illustrated in FIG. 5. With such a shape, when the outer surface portion 25 is formed into the side wall portion 7, the outer surface portion 25 can be simultaneously formed over the entire length. Note that the reference numeral 31a in FIG. 5 denotes a die jaw portion.

Examples

[0034] A press-forming analysis by FEM for confirming the effect of the present invention has been performed, which will be described below. A press-forming analysis was performed on the press-formed part 1 having the top portion 3 curved in a concave shape in a side view and the side wall portion 7 continuous with the top portion 3 as illustrated in FIG. 6 with use of a 980 MPa-class steel sheet having a sheet thickness of 1.4 mm so that the sheet thickness distribution was determined. The dimensions of respective portions of the press-formed part 1 were as described in FIG. 6. The press-forming analysis was performed by changing the shape of the outer surface portion 25 of the intermediate forming part 19 (FIG. 2) in addition to the press-forming analysis on the conventional example formed by one step as illustrated in FIG. 8, thereby determining the maximum sheet thickness increase rate of the ridge line portion 23 and the maximum sheet thickness decrease rate of the distal end portion of the side wall of the press-formed part 1 of a target shape. Note that it has been known that a wrinkle or fold is generated when the maximum sheet thickness increase rate exceeds 8%, and cracking occurs when the maximum sheet thickness decrease rate exceeds 12.0%, in the press-formed part 1 of FIG. 6. The analysis results are shown in Table 1. In Table 1, the height of the step-shaped portion 17 at the bottom position of the concave curve of the intermediate top portion 21 and the height of the step-shaped portion 17 at the end portion of the intermediate forming part 19 are shown as the step height (mm).

Table 1

No.	The number of pressing steps	Shape of outer surface portion	Intermediate forming part		Press-formed part (Target shape)		Remarks
			Step height (mm)		Maximum sheet thickness increase rate at punch shoulder R portion (%)	Maximum sheet thickness decrease rate at distal end portion of side wall (%)	
			Bottom of concave curve	End portion			
1	1	-	-		10	12.3	Conventional example
2	2	Convex chevron	3	20	Cracking at distal end of outer surface portion in intermediate forming step		Comparative example
3	2	Concave	3	1	6.4	12	Invention example
4	2	Concave	5	3	5.9	11.5	Invention example
5	2	Concave	8	5	5.2	11.6	Invention example
6	2	Concave Parallel to curve of intermediate top portion	8	8	3.7	11.4	Invention example
7	2	Concave	12	10	3	11	Invention example
8	2	Concave Parallel to curve of intermediate top portion	11	11	3.1	10.8	Invention example
9	2	Concave	15	12	3.2	11	Invention example

(continued)

No.	The number of pressing steps	Shape of outer surface portion	Intermediate forming part		Press-formed part (Target shape)		Remarks
			Step height (mm)		Maximum sheet thickness increase rate at punch shoulder R portion (%)	Maximum sheet thickness decrease rate at distal end portion of side wall (%)	
			Bottom of concave curve	End portion			
10	2	Concave	20	15	3.7	11.5	Invention example
11	2	Concave Parallel to curve of intermediate top portion	20	20	4	12	Invention example

[0035] In the conventional example shown in No. 1 in which the top portion 3 and the side wall portion 7 were press-formed by one step, the maximum sheet thickness increase rate of the punch shoulder R portion 5 was 10.0%, and a wrinkle and a fold was generated. The maximum sheet thickness decrease rate at the distal end portion of the side wall was 12.3%, and cracking occurred. No. 2 representing a comparative example is a case where the outer surface portion 25 of the intermediate forming part 19 had a convex chevron shape pointing the top portion 3 as in Patent Literature 1. In this case, cracking occurred at the distal end of the outer surface portion 25 having the convex chevron shape during the press forming of the intermediate forming part 19, and the press forming had to be stopped.

[0036] In the examples of the invention shown in No. 3 to No. 11, the intermediate forming part 19 having the step-shaped portion 17 was formed first and the intermediate forming part 19 was subsequently formed into a target shape. The outer surface portion 25 had a concavely curved shape similarly to the top portion 3, and the height of the step-shaped portion 17 was changed in the range from 1 mm to 20 mm.

[0037] In any of the examples of the invention in No. 3 to No. 11, the maximum sheet thickness increase rate at the punch shoulder R portion 5 of the target shape and the maximum sheet thickness decrease rate at the distal end portion of the side wall were reduced as compared with the conventional example No. 1. In addition, in any of the examples of the invention in No. 3 to No. 11, the maximum sheet thickness increase rate in the punch shoulder R portion 5 of the target shape was smaller than 8% at which a wrinkle was generated, and therefore the generation of wrinkles was prevented. Furthermore, in any of the examples of the invention in No. 3 to No. 11, the maximum sheet thickness decrease rate at the distal end portion of the side wall of the target shape was 12.0% or less, and therefore the occurrence of cracking was prevented. In particular, the examples of the invention in No. 7 to No. 9 showed that the maximum sheet thickness increase rate of the punch shoulder R portion 5 of the target shape can be significantly reduced and hence wrinkles and folds can be reliably prevented, by setting the step height of the intermediate forming part 19 in the range of 10 mm to 15 mm. In addition, the examples of the invention in No. 7 to No. 9 showed that the maximum sheet thickness decrease rate at the distal end portion of the side wall of the target shape can be also reduced and hence cracking can be reliably prevented, by setting the step height of the intermediate forming part 19 in the range of 10 mm to 15 mm.

Industrial Applicability

[0038] The present invention can provide a method of manufacturing a press-formed part including at least a top portion having a concave curved portion that curves concavely in a side view and a side wall portion continuous from the top portion via a punch shoulder R portion, the method capable of suppressing cracking of the press-formed part, or preventing wrinkles and folds.

Reference Signs List

[0039]

1 Press-formed part
3 Top portion
5 Punch shoulder R portion
7 Side wall portion

9 Punch
11 Pad
13 Die
13a Die jaw portion
13b Die shoulder
15 Blank
17 Step-shaped portion
19 Intermediate forming part
21 Intermediate top portion
23 Ridge line portion
25 Outer surface portion
27 Step-forming punch
29 Step-forming die
31 Die (another aspect)
31a Die jaw portion
31b Die shoulder
33 Punch shoulder

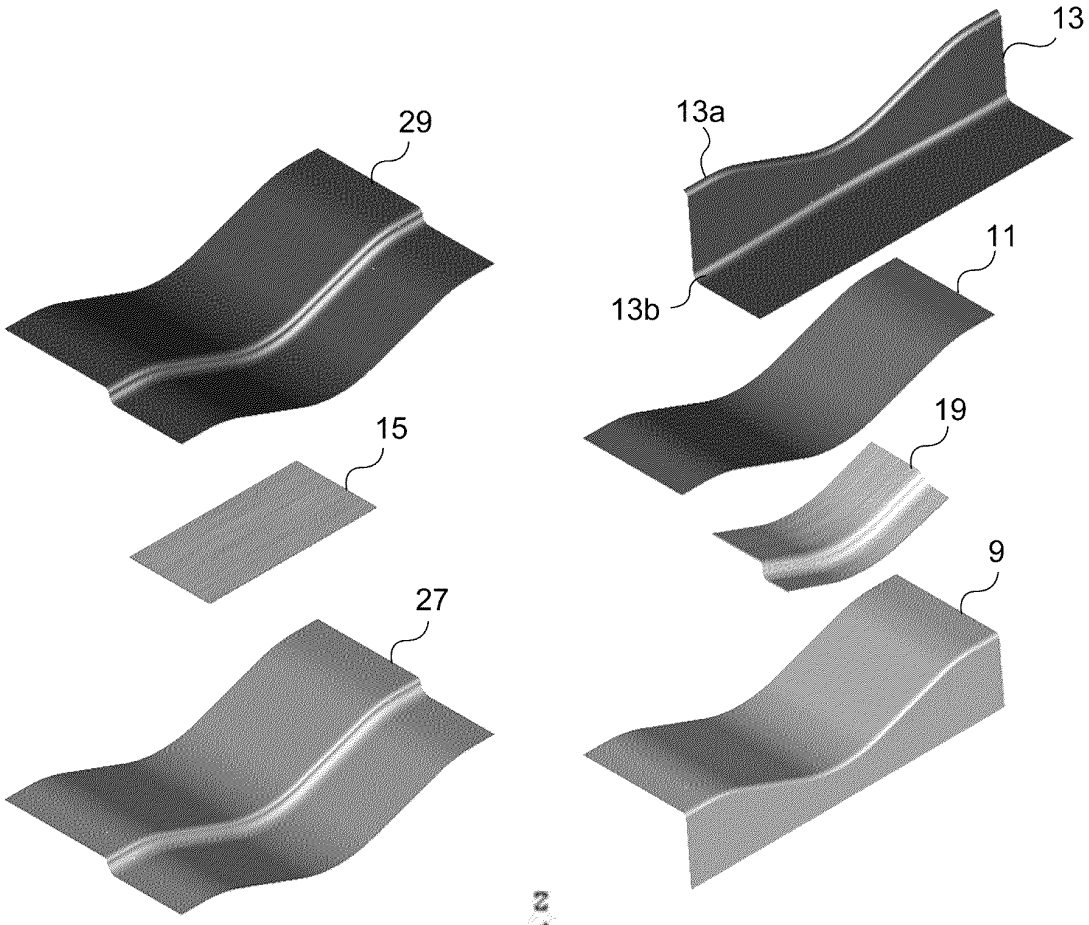
Claims

1. A method of manufacturing a press-formed part including at least a top portion having a concave curved portion that curves concavely in a side view and a side wall portion continuous from the top portion via a punch shoulder R portion, the method comprising:

   a first forming step of press-forming an intermediate forming part including an intermediate top portion curved in the same direction as the top portion, a step-shaped portion formed of a step which is continuous with a ridge line portion formed at a portion corresponding to the punch shoulder R portion, and an outer surface portion that extends outward continuously from the step-shaped portion and curves in the same direction as the intermediate top portion; and
   a second forming step of press-forming the intermediate forming part into the press-formed part.

2. The method of manufacturing a press-formed part according to claim 1, wherein a radius of curvature of the ridge line portion of the intermediate forming part is greater than or equal to a radius of curvature of the punch shoulder R portion of the press-formed part.

FIG.1



(a) INTERMEDIATE FORMING STEP

(b) TARGET FORMING STEP

FIG.2

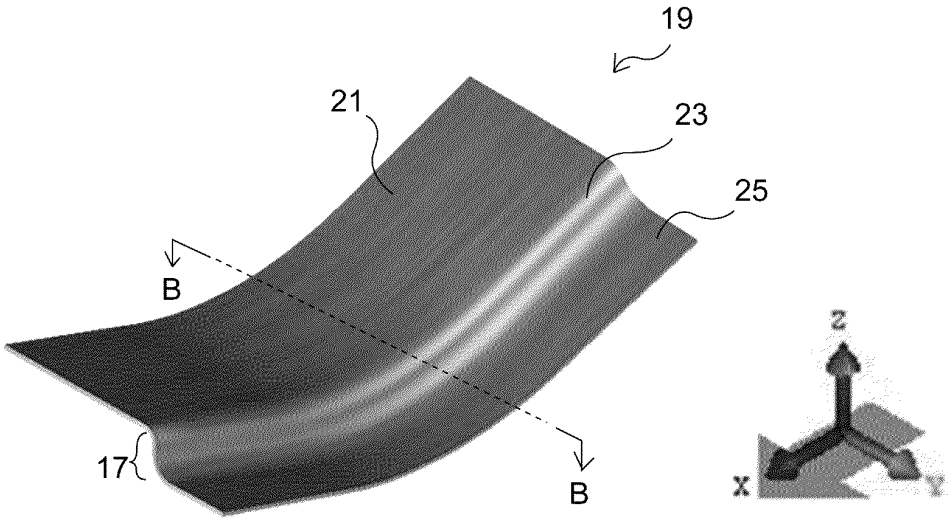


FIG.3

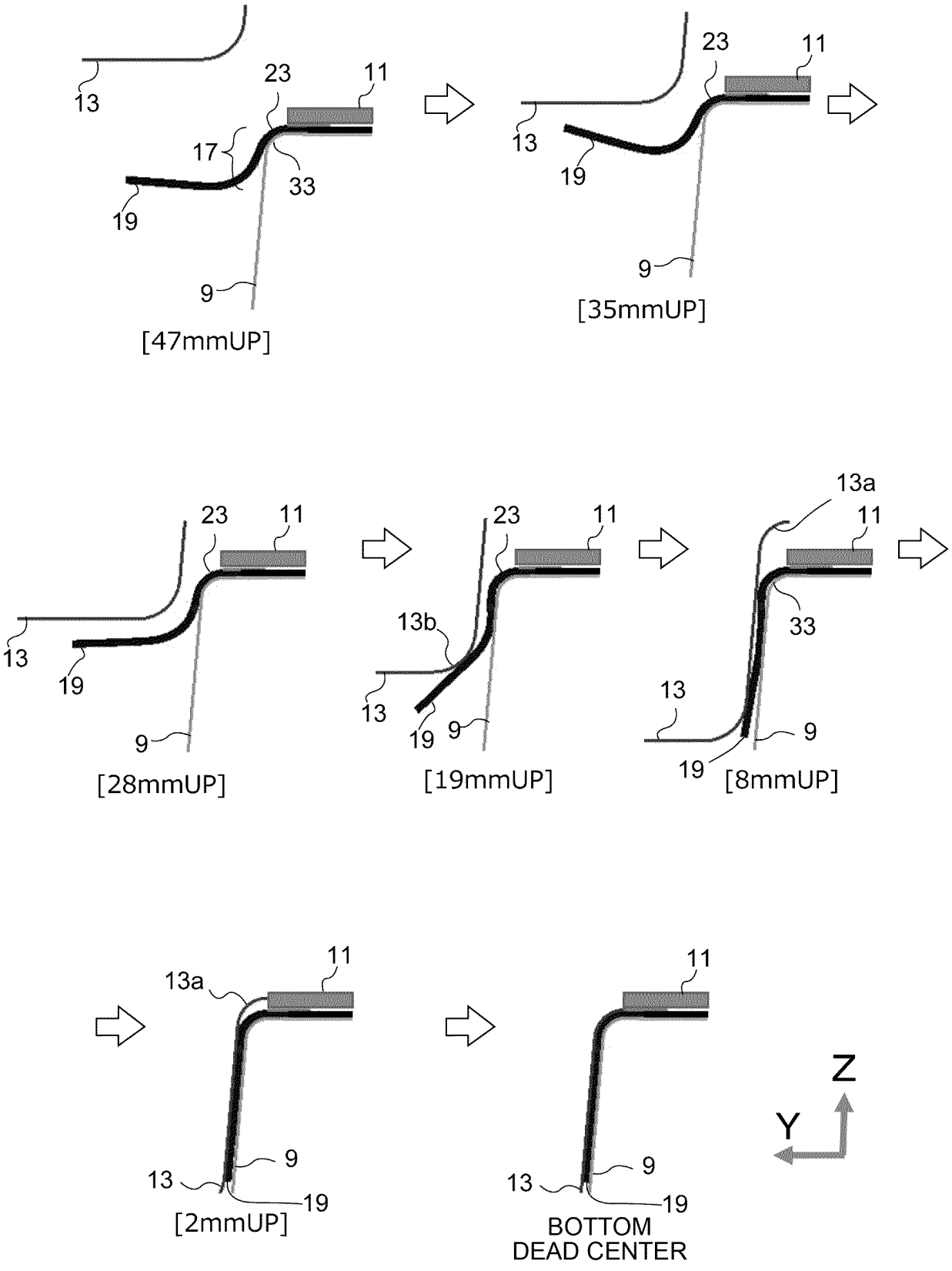
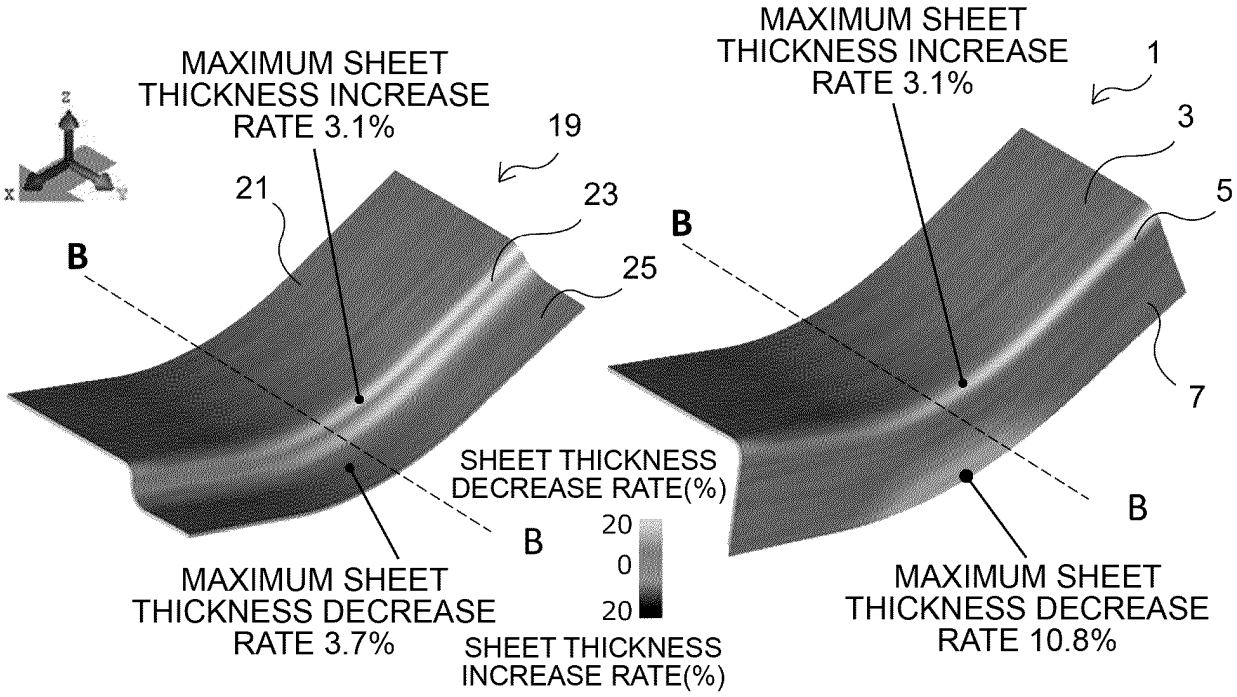

13
23
11
17
33
19
9
[47mmUP]
[35mmUP]
[28mmUP]
13b
[19mmUP]
13a
[8mmUP]
[2mmUP]
BOTTOM
DEAD CENTER
Z
Y

FIG.4



(a) FIRST FORMING STEP

(b) SECOND FORMING STEP

FIG.5

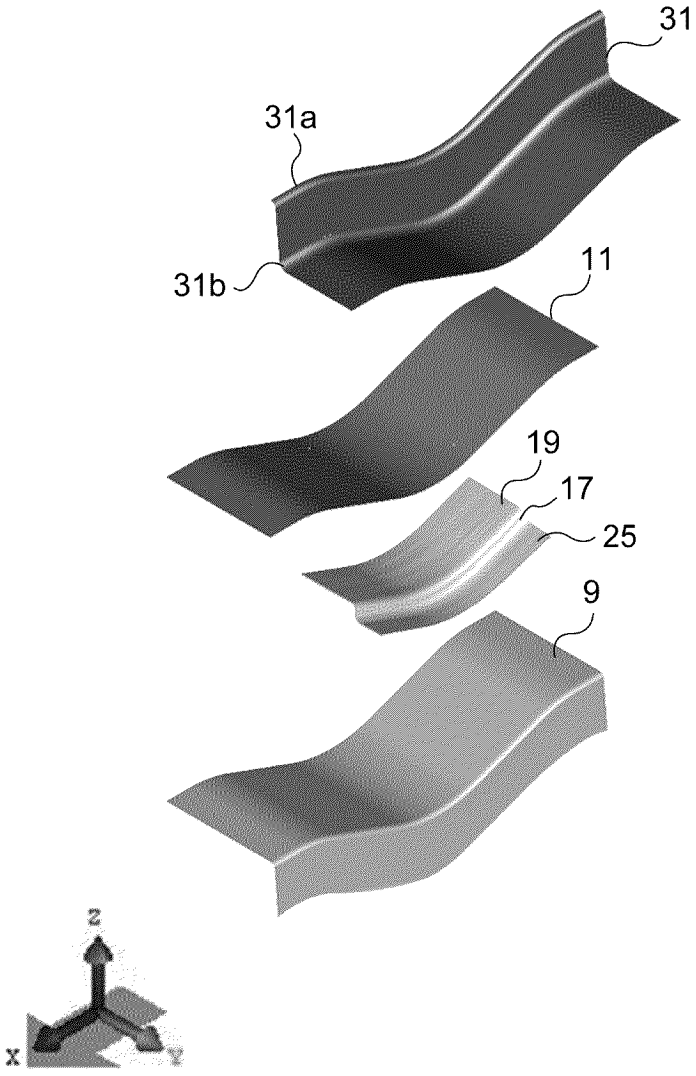


FIG.6

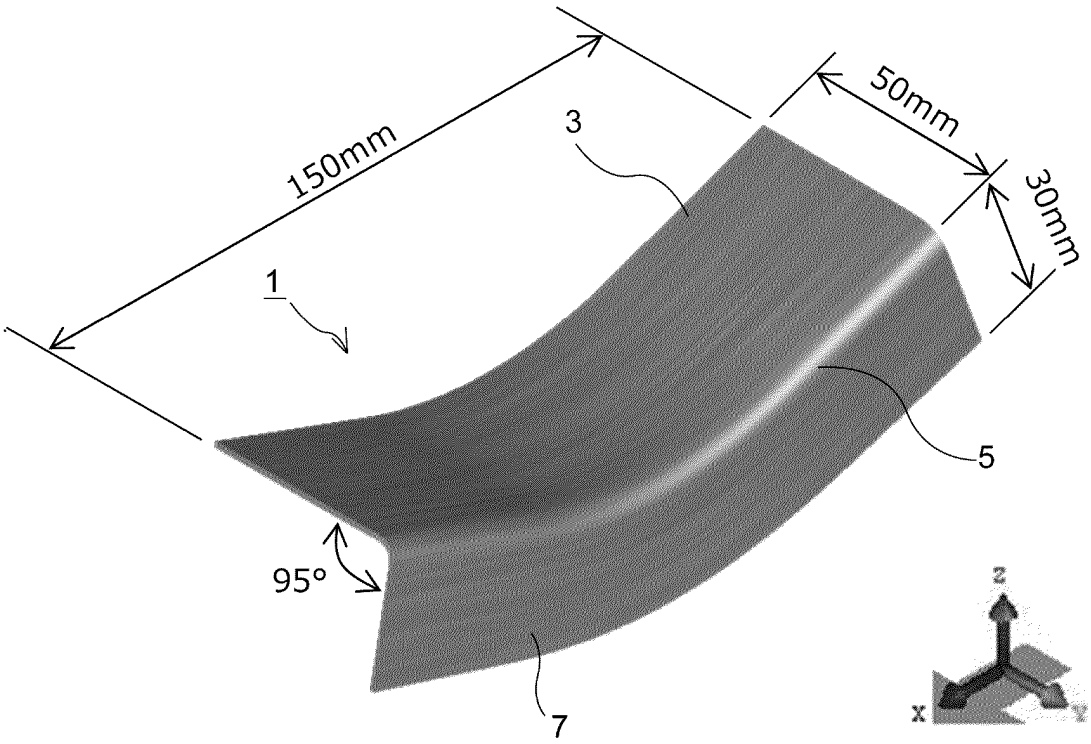


FIG.7

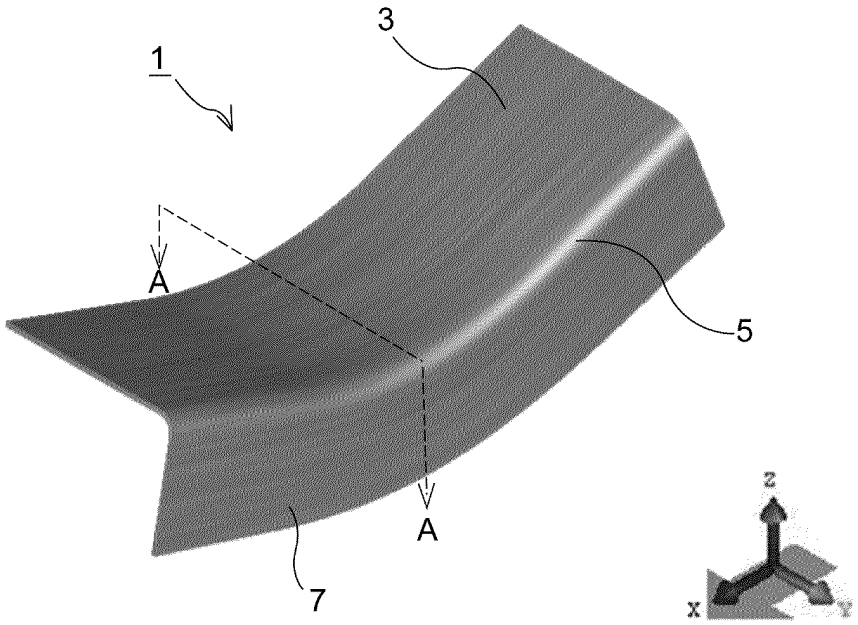


FIG.8

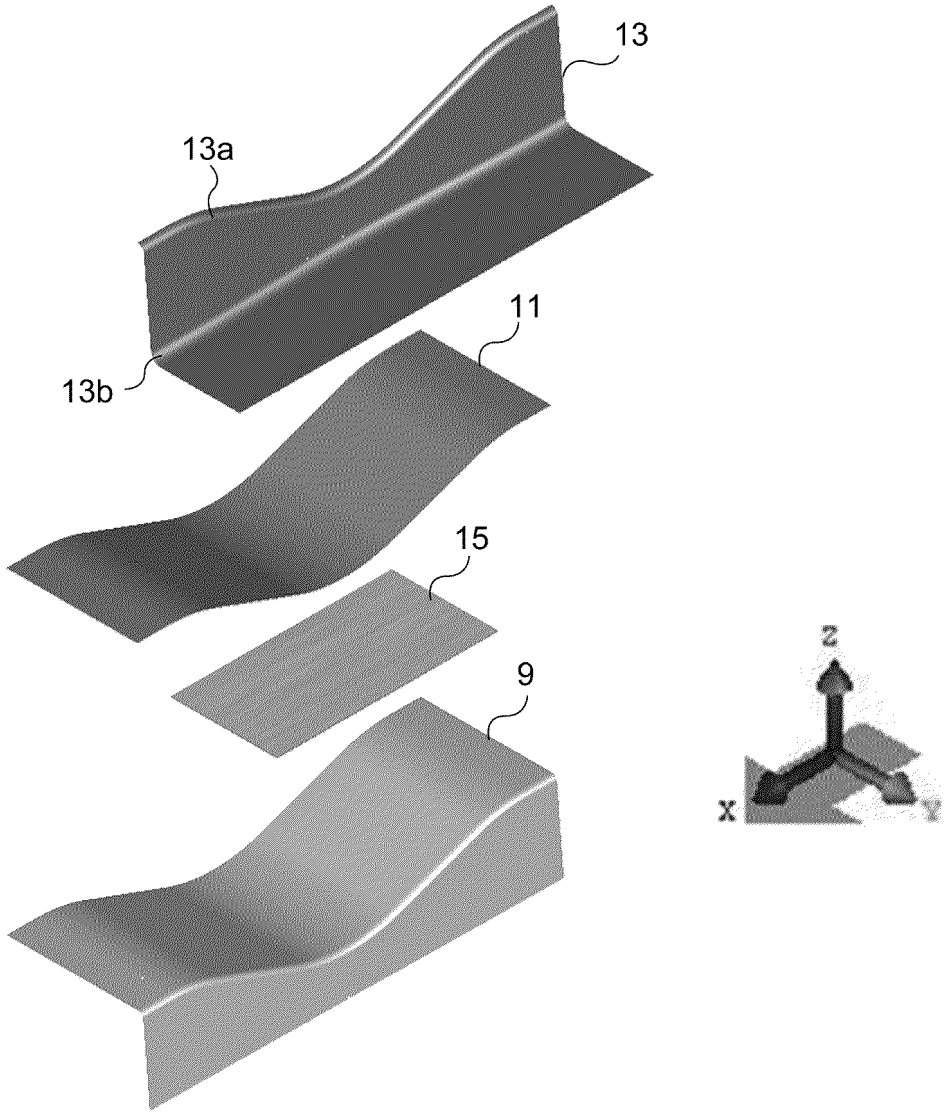


FIG.9

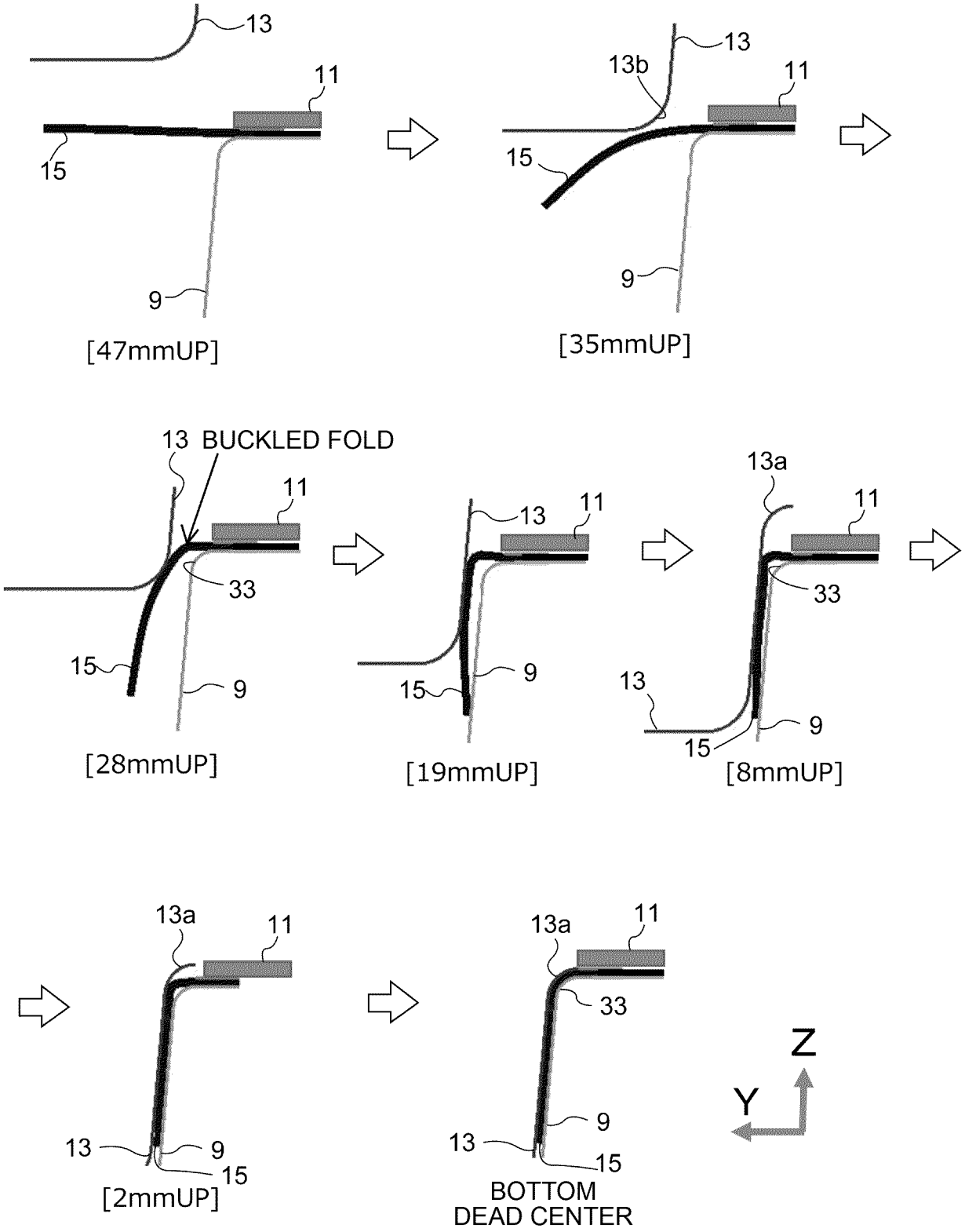
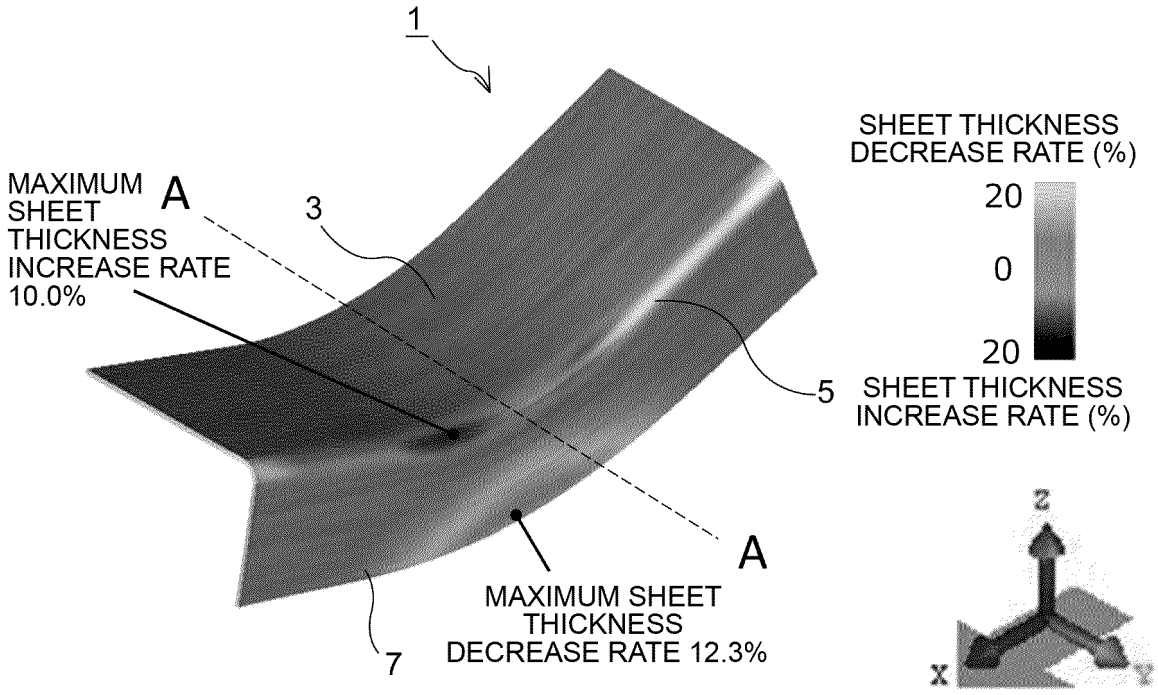

13
11
15
9
[47mmUP]
13b
[35mmUP]
13 BUCKLED FOLD
33
[28mmUP]
[19mmUP]
13a
[8mmUP]
[2mmUP]
BOTTOM
DEAD CENTER
Z
Y

FIG.10


1
MAXIMUM SHEET THICKNESS INCREASE RATE 10.0%
A
3
5
A
7
MAXIMUM SHEET THICKNESS DECREASE RATE 12.3%
SHEET THICKNESS DECREASE RATE (%)
20
0
20
SHEET THICKNESS INCREASE RATE (%)
Z
X
Y

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2023/020950

A. CLASSIFICATION OF SUBJECT MATTER

B21D 22/26(2006.01)i; ***B21D 53/88***(2006.01)i
FI: B21D22/26 C; B21D22/26 D; B21D53/88

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)

B21D22/26; B21D53/88

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 1971-2023
Registered utility model specifications of Japan 1996-2023
Published registered utility model applications of Japan 1994-2023

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	JP 2017-042826 A (JFE STEEL CORP) 02 March 2017 (2017-03-02) paragraphs [0007]-[0057], fig. 1-8	1-2
A	JP 2011-206789 A (KOBE STEEL LTD) 20 October 2011 (2011-10-20) paragraphs [0019]-[0062], fig. 1-9	1-2
A	WO 2020/105647 A1 (NIPPON STEEL CORP) 28 May 2020 (2020-05-28) paragraphs [0027]-[0070], fig. 1-21	1-2
A	JP 2015-027698 A (JFE STEEL CORP) 12 February 2015 (2015-02-12) entire text, all drawings	1-2
A	WO 2014/097745 A1 (JFE STEEL CORP) 26 June 2014 (2014-06-26) entire text, all drawings	1-2

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 July 2023	**08 August 2023**
Name and mailing address of the ISA/JP **Japan Patent Office (ISA/JP)** **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2023/020950

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2017-042826 A	02 March 2017	(Family: none)	
JP 2011-206789 A	20 October 2011	(Family: none)	
WO 2020/105647 A1	28 May 2020	(Family: none)	
JP 2015-027698 A	12 February 2015	US 2016/0121384 A1 entire text, all drawings WO 2014/208181 A1 EP 3015185 A1 CN 105358269 A KR 10-2016-0010599 A MX 2015017646 A	
WO 2014/097745 A1	26 June 2014	US 2015/0298193 A1 entire text, all drawings EP 2933034 A1 KR 10-2015-0080572 A CN 104870117 A	

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2014097745 A **[0006]**