(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 213 832 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
06.09.2017 Bulletin 2017/36

(21) Application number: **15855067.3**

(22) Date of filing: **13.10.2015**

(51) Int Cl.:
B21D 22/14 *(2006.01)* ***B21D 37/16*** *(2006.01)*

(86) International application number:
PCT/JP2015/005181

(87) International publication number:
WO 2016/067537 (06.05.2016 Gazette 2016/18)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA

(30) Priority: **29.10.2014 JP 2014219846**

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(54) **SPIN-MOLDING METHOD**

(57) A spinning forming method is a method of forming a formation target region of a plate into a tapered shape by using a processing tool while rotating the plate. The processing tool is moved from an inside edge of the formation target region to an outside edge of the formation target region while being pressed against the plate. The plate is rotated in a state where a position of the processing tool is fixed at the outside edge.

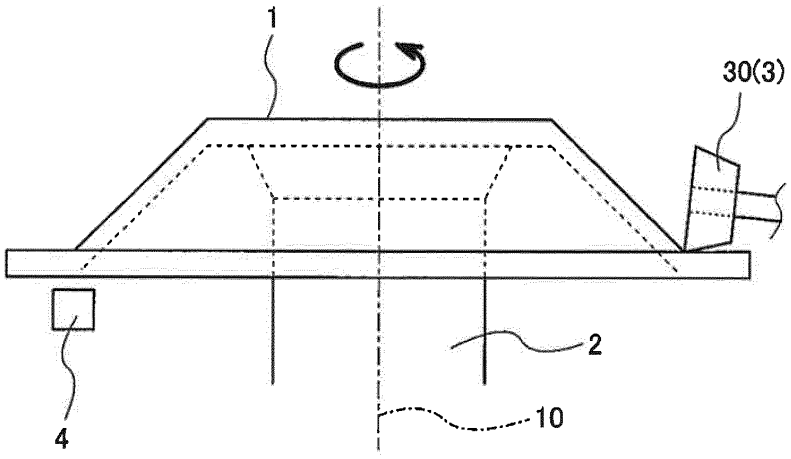

Fig. 1

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Description

Technical Field

[0001] The present invention relates to a spinning forming method of processing a plate.

Background Art

[0002] Conventionally known is a spinning forming method of forming a formation target region of a plate into a tapered shape by using a processing tool while rotating the plate (see PTL 1, for example).

Citation List

Patent Literature

[0003] PTL 1: Japanese Laid-Open Patent Application Publication No. 2011-218427

Summary of Invention

Technical Problem

[0004] According to a typical spinning forming method, while the processing tool is being pressed against the plate at a constant axial sending speed (a movement speed of the processing tool in a direction along a rotation axis of the plate), the processing tool is moved at a constant radial traveling speed (a movement speed of the processing tool in a direction vertically away from the rotation axis of the plate) from an inside edge of the formation target region of the plate toward an outside edge of the formation target region. Immediately after the processing tool reaches the outside edge of the formation target region, the processing tool is separated from the plate.

[0005] However, according to this method, a depression (a press mark by the processing tool) corresponding to the shape of the processing tool is formed at a position the plate from which position the processing tool is separated.

[0006] An object of the present invention is to provide a spinning forming method capable preventing the formation of the press mark by the processing tool.

Solution to Problem

[0007] To solve the above problems, a spinning forming method according to one aspect of the present invention is a spinning forming method of forming a formation target region of a plate into a tapered shape by using a processing tool while rotating the plate, the spinning forming method including: moving the processing tool from an inside edge of the formation target region to an outside edge of the formation target region while pressing the processing tool against the plate; and rotating the plate in a state where a position of the processing tool is fixed at the outside edge.

[0008] According to the above configuration, the processing tool stands by at the outside edge (i.e., a forming finish point) of the formation target region. Therefore, the formation of the press mark by the processing tool can be prevented.

[0009] A spinning forming method according to another aspect of the present invention is a spinning forming method of forming a formation target region of a plate into a tapered shape by using a processing tool while rotating the plate, the spinning forming method including: moving the processing tool from an inside edge of the formation target region to an outside edge of the formation target region while pressing the processing tool against the plate; and reducing an axial sending speed and radial traveling speed of the processing tool when the processing tool is located in a vicinity of the outside edge.

[0010] According to the above configuration, the plate is slowly processed in the vicinity of the outside edge (i.e., the forming finish point) of the formation target region. Therefore, the formation of the press mark by the processing tool can be prevented.

[0011] The pressing of the processing tool against the plate may be performed while locally heating a portion of the plate, the portion being located on a same circumference as a portion of the plate against which portion the processing tool is pressed. According to this configuration, the portion of the plate against which portion the processing tool is pressed can be processed more intensively than a case where the plate is not heated and a case where the plate is entirely heated. Therefore, the operation of the processing tool for obtaining a desired shape is facilitated.

[0012] The processing tool may be a forming roller having a trapezoidal cross section that decreases in diameter in a direction away from a rotation axis of the plate, and the pressing of the forming roller against the plate may be performed in a state where a large-diameter portion of the forming roller is in point contact with the plate, and the forming roller is kept in such a posture that an angle between a side surface of the forming roller and a plane orthogonal to the rotation axis of the plate is not less than 1° and not more than 30°. According to this configuration, warp-up of a portion of the plate which portion is located outside the portion against which the processing tool is pressed can be restricted by the side surface of the forming roller.

[0013] The pressing of the processing tool against the plate may be performed in a state where a portion of the plate against which portion the processing tool is pressed is floating. According to this configuration, it is unnecessary to use a shaping die (mandrel) which has been often used in conventional spinning forming methods, so that the manufacturing cost can be reduced.

Advantageous Effects of Invention

[0014] The present invention can prevent the formation of the press mark by the processing tool.

Brief Description of Drawings

[0015]

Fig. 1 is an explanatory diagram of a spinning forming method according to one embodiment of the present invention.

Fig. 2A is a cross-sectional view of a plate immediately before spinning forming starts. Fig. 2B is a cross-sectional view of the plate when the spinning forming finishes.

Fig. 3 is a diagram showing a state where the processing tool is pressed against the plate immediately before the spinning forming finishes.

Fig. 4 is a diagram showing the plate after the spinning forming in a case where the processing tool is separated from the plate immediately after the processing tool reaches the outside edge of the formation target region.

Fig. 5 is a diagram showing the plate after the spinning forming in a case where the processing tool stands by when the processing tool reaches the outside edge of the formation target region and or a case where the axial sending speed and radial traveling speed of the processing tool are reduced from slightly before the processing tool reaches the outside edge of the formation target region.

Description of Embodiments

[0016] Fig. 1 is an explanatory diagram of a spinning forming method according to one embodiment of the present invention. This spinning forming method is a method of forming a formation target region R (see Fig. 2A) of a plate 1 into a tapered shape by using a processing tool 3 while rotating the plate 1.

[0017] The plate 1 is, for example, a flat circular plate. However, the shape of the plate 1 may be a polygonal shape or an oval shape. Further, the plate 1 does not necessarily have to be entirely flat. For example, the thickness of a center portion of the plate 1 may be smaller or larger than the thickness of a peripheral portion of the plate 1, and the plate 1 may be entirely or partially processed into a tapered shape in advance. A material of the plate 1 is not especially limited and is, for example, a titanium alloy.

[0018] The plate 1 is fixed to a rotating shaft 2. To be specific, a center line of the rotating shaft 2 corresponds to a rotation axis 10 of the plate 1. The rotation axis 10 of the plate 1 may be parallel to a vertical direction, may be parallel to a horizontal direction, or may extend in an oblique direction. The rotating shaft 2 is rotated by a rotating mechanism (not shown).

[0019] According to the present embodiment, a shaping die (mandrel) is not disposed at the rotating shaft 2. Only the center portion of the plate 1 is supported by the rotating shaft 2 not only before the start of the spinning forming but also during the spinning forming. To be specific, below-described pressing of the processing tool 3 against the plate 1 is performed in a state where a portion of the plate 1 against which portion the processing tool 3 is pressed is floating. According to this configuration, it is unnecessary to use the shaping die (mandrel) which has been commonly used in conventional spinning forming methods, so that the manufacturing cost can be reduced. However, the shaping die (mandrel) may be disposed at the rotating shaft 2, and the portion of the plate 1 against which portion the processing tool 3 is pressed may be supported by the shaping die during the spinning forming.

[0020] As shown in Figs. 2A and 2B, the processing tool 3 is moved from an inside edge (i.e., a forming start point) Rs of the formation target region R toward an outside edge (i.e., a forming finish point) Re of the formation target region R while being pressed against the plate 1. The processing tool 3 is moved in a direction along the rotation axis 10 of the plate 1 at a specific axial sending speed corresponding to each position on the plate 1 to be pressed against the plate 1. Further, the processing tool 3 is moved in a direction vertically away from the rotation axis 10 of the plate 1 at a specific radial traveling speed corresponding to each position on the plate 1. In the present embodiment, used as the processing tool 3 is a forming roller 30 that follows the rotation of the plate 1 to rotate. However, the processing tool 3 is not limited to the forming roller 30 and may be, for example, a spatula.

[0021] More specifically, the forming roller 30 has a trapezoidal cross section that decreases in diameter in a direction away from the rotation axis 10 of the plate 1. To be specific, the forming roller 30 includes: a large-diameter bottom surface located closer to the rotation axis 10; a small-diameter top surface located at an opposite side of the rotation axis 10; and a tapered side surface 31 connecting the bottom surface with the top surface. To be specific, an annular corner portion between the side surface 31 and the bottom surface is a large-diameter portion, and an annular corner portion between the side surface 31 and the top surface is a small-diameter portion. It should be noted that a forming roller having a different cross section (such as a diamond cross section or a long round cross section) may be used as the processing tool 3.

[0022] In the present embodiment in which the forming roller 30 having the trapezoidal cross section is used as the processing tool 3, the pressing of the forming roller 30 against the plate 1 is performed in a state where: the large-diameter portion of the forming roller 30 is in point contact with the plate 1; and the forming roller 30 is kept in such a posture that an angle θ (see Fig. 2A) between the side surface 31 of the forming roller 30 and a plane

(i.e., a plane parallel to the plate 1) orthogonal to the rotation axis 10 of the plate 1 is not less than 1° and not more than 30°.

[0023] Further, in the present embodiment, the pressing of the processing tool 3 against the plate 1 is performed while a portion of the plate 1 is locally heated by a heater 4, the portion being located on the same circumference as the portion against which the processing tool 3 is pressed. This expression "on the same circumference" denotes that the portion against which the processing tool 3 is pressed and the portion heated by the heater 4 are located within a ring-shaped range defined around the rotation axis 10 of the plate 1 and having a certain width. For example, the portion heated by the heater 4 may be located within a range centering the portion against which the processing tool 3 is pressed, the range corresponding to ±10% of a distance from the rotation axis 10 of the plate 1 to the portion against which the processing tool 3 is pressed.

[0024] In the present embodiment, the heater 4 is disposed at an opposite side of the processing tool 3 across the plate 1 so as to heat the plate 1 from a rear side. However, the heater 4 may be disposed at the same side as the processing tool 3 relative to the plate 1 so as to heat the plate 1 from a front side.

[0025] The heater 4 is desirably a high-frequency induction heater including a coil portion to which an alternating voltage having a high frequency of 5 k to 400 kHz is applied. In such a high-frequency induction heater, the coil portion desirably extends in a rotational direction of the plate 1 and has a doubled circular-arc shape facing the plate 1 so as to be able to perform local heating of the plate 1 continuously in the rotational direction of the plate 1. It should be noted that a gas burner may be used as the heater 4.

[0026] In the spinning forming method of the present embodiment, when the processing tool 3 reaches the outside edge Re of the formation target region R, the plate 1 is rotated in a state where the position of the processing tool 3 is fixed. Fig. 3 shows a state where the processing tool 3 is pressed against the plate 1 immediately before the spinning forming finishes. As with conventional arts, when the processing tool 3 is separated from the plate 1 immediately after the processing tool 3 reaches the outside edge Re of the formation target region R, as shown in Fig. 4, a depression (a press mark 11 by the processing tool 3) corresponding to the shape of the processing tool 3 is formed at a position of the plate 1 from which position the processing tool 3 is separated. However, according to the present embodiment, the processing tool 3 stands by at the outside edge Re of the formation target region R. Therefore, as shown in Fig. 5, the formation of the press mark 11 (see Fig. 4) by the processing tool 3 can be prevented.

[0027] A portion of the plate 1 which portion is located outside the portion against which the processing tool 3 is pressed may warp up toward the processing tool 3. In this case, the forming roller 30 having the trapezoidal cross section is used, and the posture of the forming roller 30 is kept as in the present embodiment. With this, the warp-up of the outside portion of the plate 1 can be restricted by the side surface 31 of the forming roller 30.

Modified Example

[0028] The present invention is not limited to the above embodiment, and various modifications may be made within the scope of the present invention.

[0029] For example, in the above embodiment, the processing tool 3 stands by when the processing tool 3 reaches the outside edge Re of the formation target region R. However, the axial pressing speed and radial traveling speed of the processing tool 3 may be reduced in the vicinity of the outside edge Re. This expression "the vicinity of the outside edge Re" denotes a range which spreads from the outside edge Re inward to a portion corresponding to one fifth of the formation target region R as an upper limit and may be set arbitrarily. For example, when the processing tool 3 reaches a finish close point adjacent to the outside edge Re of the formation target region R, the axial sending speed and radial traveling speed of the processing tool 3 may be reduced to not more than half the axial sending speed and radial traveling speed of the processing tool 3 before the processing tool 3 reaches the finish close point.

[0030] According to the above configuration, the plate 1 is slowly processed in the vicinity of the outside edge Re of the formation target region R. Therefore, as shown in Fig. 5, the formation of the press mark 11 (see Fig. 4) by the processing tool 3 can be prevented.

[0031] Further, the pressing of the processing tool 3 against the plate 1 may be performed in a state where the plate 1 is entirely heated or a state where the plate 1 is not heated instead of a state where the plate 1 is locally heated. However, in a case where the plate 1 is locally heated as in the above embodiment, the portion of the plate 1 against which portion the processing tool 3 is pressed can be processed more intensively than the case where the plate 1 is not heated or the case where the plate 1 is entirely heated. Therefore, the operation of the processing tool 3 for obtaining a desired shape is facilitated.

Reference Signs List

[0032]

1	plate
10	rotation axis
3	processing tool
30	forming roller
31	side surface

Claims

1. A spinning forming method of forming a formation target region of a plate into a tapered shape by using a processing tool while rotating the plate, the spinning forming method comprising:

   moving the processing tool from an inside edge of the formation target region to an outside edge of the formation target region while pressing the processing tool against the plate; and
   rotating the plate in a state where a position of the processing tool is fixed at the outside edge.

2. The spinning forming method according to claim 1, wherein the pressing of the processing tool against the plate is performed while locally heating a portion of the plate, the portion being located on a same circumference as a portion of the plate against which portion the processing tool is pressed.

3. The spinning forming method according to claim 1 or 2, wherein:

   the processing tool is a forming roller having a trapezoidal cross section that decreases in diameter in a direction away from a rotation axis of the plate; and
   the pressing of the forming roller against the plate is performed in a state where a large-diameter portion of the forming roller is in point contact with the plate, and the forming roller is kept in such a posture that an angle between a side surface of the forming roller and a plane orthogonal to the rotation axis of the plate is not less than 1° and not more than 30°.

4. The spinning forming method according to any one of claims 1 to 3, wherein the pressing of the processing tool against the plate is performed in a state where a portion of the plate against which portion the processing tool is pressed is floating.

5. A spinning forming method of forming a formation target region of a plate into a tapered shape by using a processing tool while rotating the plate, the spinning forming method comprising:

   moving the processing tool from an inside edge of the formation target region to an outside edge of the formation target region while pressing the processing tool against the plate; and
   reducing an axial sending speed and radial traveling speed of the processing tool when the processing tool is located in a vicinity of the outside edge.

6. The spinning forming method according to claim 5, wherein the pressing of the processing tool against the plate is performed while locally heating a portion of the plate, the portion being located on a same circumference as a portion of the plate against which portion the processing tool is pressed.

7. The spinning forming method according to claim 5 or 6, wherein:

   the processing tool is a forming roller having a trapezoidal cross section that decreases in diameter in a direction away from a rotation axis of the plate; and
   the pressing of the forming roller against the plate is performed in a state where a large-diameter portion of the forming roller is in point contact with the plate, and the forming roller is kept in such a posture that an angle between a side surface of the forming roller and a plane orthogonal to the rotation axis of the plate is not less than 1° and not more than 30°.

8. The spinning forming method according to any one of claims 5 to 7, wherein the pressing of the processing tool against the plate is performed in a state where a portion of the plate against which portion the processing tool is pressed is floating.

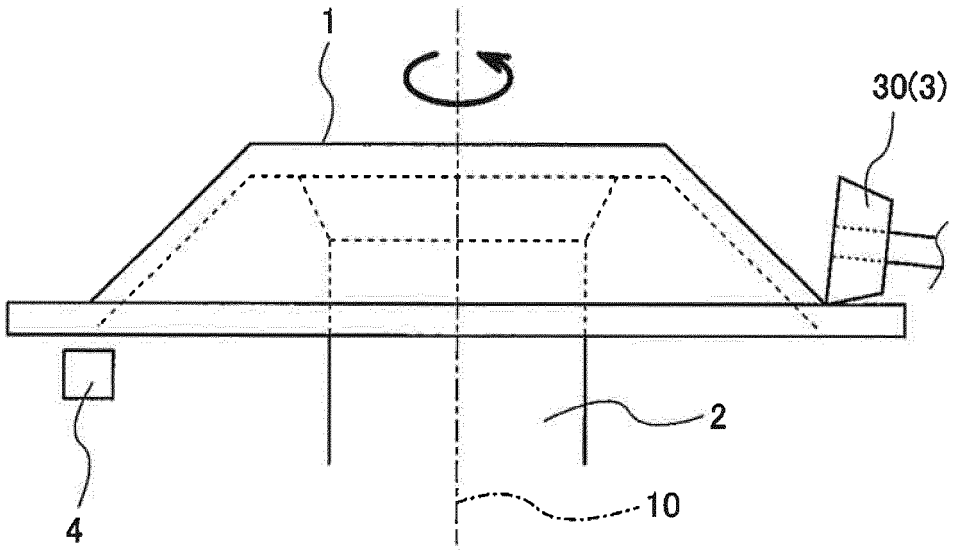


Fig. 1

Fig. 2A

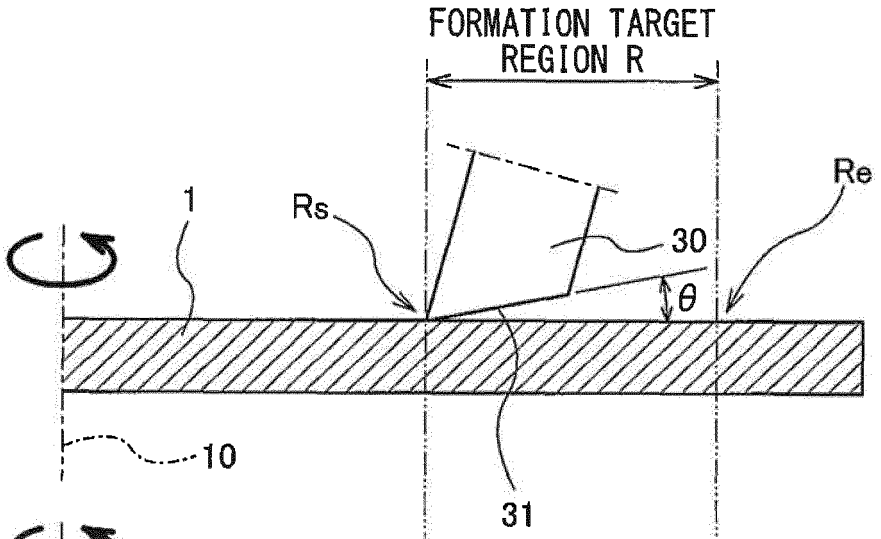
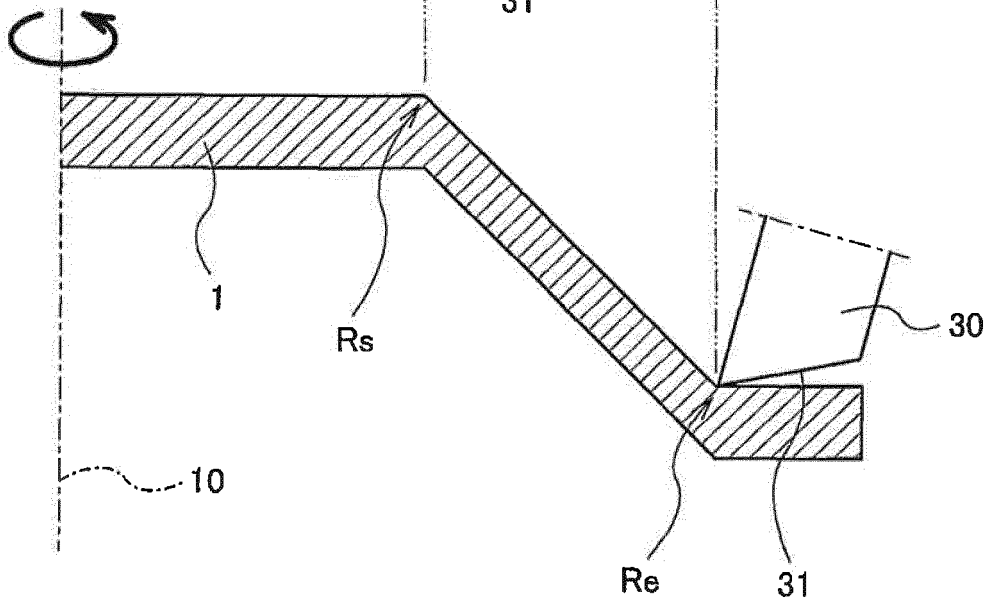


Fig. 2B



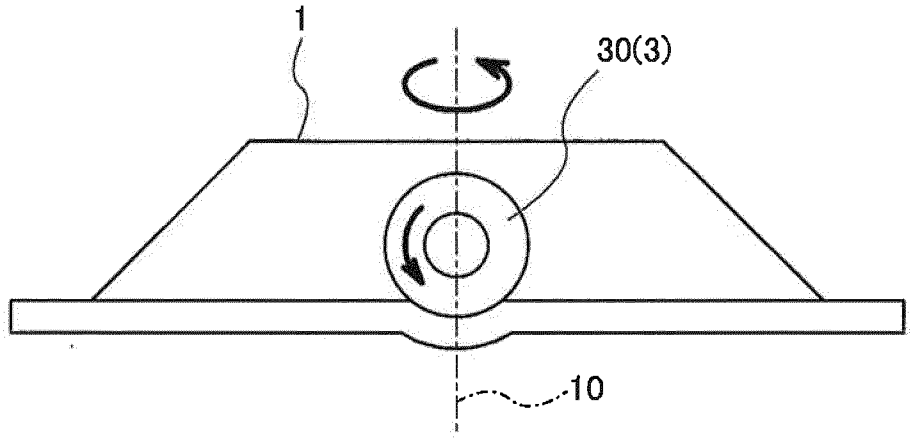


Fig. 3

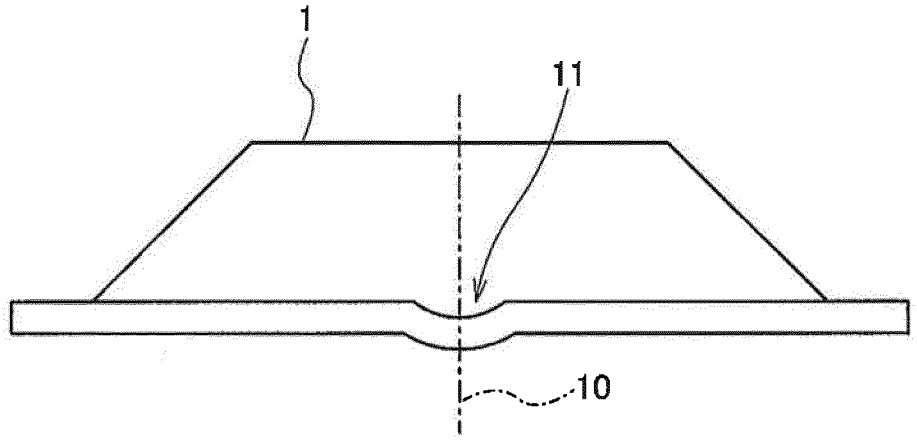


Fig. 4

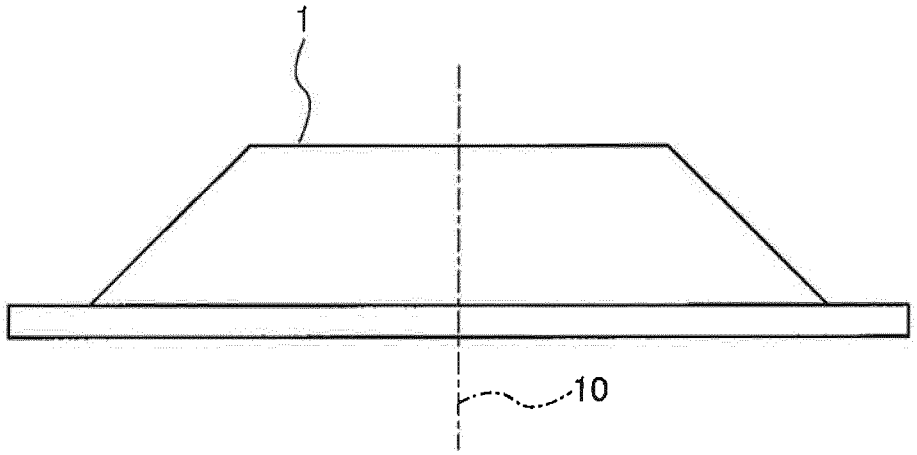


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/005181

A. CLASSIFICATION OF SUBJECT MATTER
B21D22/14(2006.01)i, *B21D37/16*(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)
B21D22/14, B21D37/16

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 1996-2015
Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

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 2014-117735 A (Kawasaki Heavy Industries, Ltd.), 30 June 2014 (30.06.2014), fig. 1 & WO 2014/097551 A1 & CN 104837575 A	1-8
A	JP 2005-254253 A (Toyota Motor Corp.), 22 September 2005 (22.09.2005), fig. 5 (Family: none)	1-8
A	JP 2002-292433 A (Sumitomo Metal Steel Products Inc.), 08 October 2002 (08.10.2002), paragraph [0007]; fig. 4 (Family: none)	1-8

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

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Date of the actual completion of the international search	Date of mailing of the international search report
18 November 2015 (18.11.15)	01 December 2015 (01.12.15)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/005181

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 11-285750 A (Toyota Motor Corp.), 19 October 1999 (19.10.1999), claims (Family: none)	1-8
A	EP 0081700 A1 (AIR PRODUCTS AND CHEMICALS, INC.), 22 June 1983 (22.06.1983), fig. 5 to 8 (Family: none)	1-8

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2011218427 A **[0003]**