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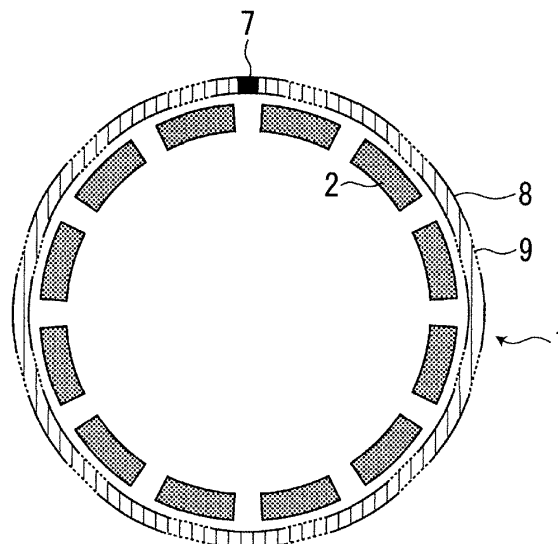
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(54) **METHOD FOR MANUFACTURING STEEL PIPE**

(57) In a method of producing a steel pipe by shaping a steel plate subjected to edge bending into a cylindrical form through plural times of three-point bending press in widthwise direction and welding the seams thereof to form a non-expanded pipe (1), inserting a pipe expander provided with plural expander tools (2) into an inside of the non-expanded pipe to perform pipe expanding, the expander tools (2) are pushed onto all sites of non-de-

formation areas (9) in three-point bending press to perform pipe expanding, whereby a steel pipe having an excellent roundness is produced in a high productivity. Moreover, the number of times of the three-point press bending in the above production method is $(aN - 1)$ wherein a is an integer of 1, 2 or the like when the number of the expander tools is N .

FIG. 3



Description

TECHNICAL FIELD

5 **[0001]** This invention relates to a method of producing a large-diameter and thick-walled steel pipe used in line pipe and the like.

RELATED ART

10 **[0002]** So-called UOE steel pipes are widely used as the large-diameter and thick-walled steel pipe used in the line pipe. A so-called UOE steel pipe produced by press bending a steel plate as a material having predetermined width, length and thickness into a U-shaped form, further press forming into a O-shaped form, welding the seams to form a steel pipe, and thereafter performing pipe expanding for increasing a diameter of the steel pipe to enhance a roundness. In the production method of the UOE steel pipe as mentioned above, however, a significant press force is required at steps of press-forming the steel plate into U-shaped and O-shaped forms, so that it is necessary to use a large-scale press machine.

15 **[0003]** There is developed a method of producing the large-diameter and thick-walled steel pipe by reducing the press force. For example, a method of bending a widthwise end portion of a steel plate (edge bending) and performing plural times of three-point bending press to shape the steel plate into substantially a cylindrical form, welding seams to form a steel pipe, and then inserting a pipe expander into the inside of the steel pipe to perform pipe expanding is put into practical use. The pipe expander is provided with a plurality of expander tools each having a curved surface of a divided circular arc, and has an action of arranging the form of the steel pipe to enhance the roundness by pushing the curved surface to the inner face of the steel pipe to enlarge the pipe (pipe expanding).

20 **[0004]** When the steel pipe is produced by the above method, if the number of times of the three-point bending press is increased, the roundness of the resulting steel pipe is improved, whereas a long time is required for the production of the steel pipe and the productivity is lowered. Inversely, if the number of times of the three-point bending press is decreased, the productivity is improved, but the roundness of the steel pipe is lowered. To this end, it is actual to perform the production by setting the number of times of the three-point bending press in accordance with the size of the steel pipe, for example, empirically setting to 50~60 times in case of a steel pipe having a diameter of 1200 mm.

25 **[0005]** On the other hand, there is examined a technique of decreasing the press number applied to the steel plate and providing a steel pipe with a good roundness. For example, Patent Document 1 discloses a technique wherein a steel plate are subjected to press bending with a die 4 times and further seams thereof are welded to form a steel pipe and then hot roll forming is applied to the steel pipe by heating to arrange the form thereof.

PRIOR ART DOCUMENTS

PATENT DOCUMENT

30 **[0006]** Patent Document 1: JP-A-2005-324255

SUMMARY OF THE INVENTION

TASK TO BE SOLVED BY THE INVENTION

35 **[0007]** However, the technique of Patent Document 1 requires the heating of the steel pipe, so that it is necessary to use a heating apparatus, which brings about the increase of the production cost. Also, there is a problem that excellent properties such as strength, toughness, weldability and the like provided to the raw steel plate by taking a technique of accelerated cooling or the like are deteriorated by heating the steel pipe.

40 **[0008]** The present invention is made in view of the above problems inherent to the conventional technique and is to propose a method of producing a steel pipe wherein the heating of the steel pipe is not required in the production of the large-diameter and thick-walled steel pipe by performing plural times of three-point bending press and a good roundness can be attained even if the number of times of three-point bending press is decreased.

SOLUTION FOR TASK

45 **[0009]** In the production of the steel pipe, the number of times of three-point bending press or the center to center spacing of dies thereof (feed pitch of steel plate) is usually set so as not to generate a gap in a deformation area by bending press in order to enhance the roundness of the steel pipe. Therefore, if the number of times of three-point

bending press is decreased for shortening the production time of the steel pipe, the center to center spacing of dies is increased, and hence the deformation area bent by three-point bending press is arc-like, while non-deformation area is flat, so that the roundness of the resulting steel pipe becomes low.

[0010] The inventors have turned attention to a deformation amount applied to the steel pipe in the pipe expanding and made further studies on the method for enhancing the roundness of the steel pipe produced by performing plural times of three-point bending press. As a result, it has been found out that when the steel pipe is expanded, there is a tendency that the deformation amount (expanding amount) becomes large at sites of contacting plural expander tools of the pipe expander inserted with the inside of the steel pipe, while the deformation amount becomes small at sites not contacting the expansion tool therewith.

[0011] From the above knowledge, it has been conceived that when the welded steel pipe is expanded after the three-point bending press, the non-deformation area retained at a flat state is shaped into an arc form by pushing the expander tool to the non-deformation area to perform pipe expanding and forms continuously a circular arc together with the deformation area previously shaped into an arc form by three-point bending press to thereby provide a steel pipe having a good roundness, and as a result, the invention has been accomplished. Moreover, the steel pipe after the welding and before the pipe expanding is called as "non-expanded pipe" hereinafter.

[0012] That is, the present invention proposes a method of producing a steel pipe by shaping a steel plate subjected to edge bending into a cylindrical form through plural times of three-point bending press in widthwise direction and welding seams thereof to form a non-expanded pipe, inserting a pipe expander provided with plural expander tools into an inside of the non-expanded pipe to perform pipe expanding, characterized in that the expander tools are pushed onto all sites of non-deformation areas in three-point bending press to perform pipe expanding.

[0013] The production method of the steel pipe according to the present invention is characterized in that the number of times of the three-point press bending is $(aN - 1)$ wherein a is an integer of 1, 2 or the like when the number of the expander tools is N .

EFFECT OF THE INVENTION

[0014] According to the present invention, when a large-diameter and thick-walled steel pipe is produced by performing three-point bending press, the number of times of three-point bending press can be decreased without requiring the heating of the steel pipe, so that it is possible to produce a steel pipe having an excellent roundness in a high productivity without damaging excellent properties such as strength, toughness, weldability and the like provided during the production process of the raw steel plate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

FIG. 1 illustrates a schematic view illustrating production process of a non-expanded pipe according to the present invention.

FIG. 2 illustrates a schematic view illustrating a three-point bending press method.

FIG. 3 illustrates a schematic view illustrating a steel pipe A (Invention Example) formed by expanding a non-expanded pipe having 12 non-deformation areas shaped by 11 times of three-point bending press with 12 expander tools.

FIG. 4 illustrates a schematic view illustrating a steel pipe B (Invention Example) formed by expanding a non-expanded pipe having 20 non-deformation areas shaped by 19 times of three-point bending press with 10 expander tools.

FIG. 5 illustrates a schematic view illustrating Comparative Example A of expanding a non-expanded pipe having 12 non-deformation areas shaped by 11 times of three-point bending press with 12 expander tools.

FIG. 6 illustrates a schematic view illustrating Comparative Example of expanding a non-expanded pipe after 11 times of three-point bending press with 10 expander tools.

FIG. 7 illustrates a view showing a difference m .

EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0016] The production process of the non-expanded pipe in the production method of the steel pipe according to the present invention will be described with reference to FIG. 1.

[0017] After both widthwise end portions (width L) of a steel plate 3 having a plate width W illustrated in FIG. 1(a) are curved to form bent portions (hereinafter referred to as "edge bending"), one half of the plate divided by a widthwise central line CL illustrated in FIG. 1(b) is subjected to plural times of three-point bending press 4 from one widthwise end

of the steel plate 3 toward widthwise center thereof (provided that a portion of the widthwise central line CL is left unpressed), whereby one half of the steel plate 3 is shaped into substantially a semicircular form. In the three-point bending press, the steel plate 3 is placed on two lower dies 5a, 5b arranged at a given distance and an arc-like curved surface of an upper forming tool 6 is pressed onto the steel plate 3 to perform bending work. Also, the distance between positions of pressing the upper forming tool in the three-point bending press 4 (which may be called as "feed pitch P" hereinafter) is equal distance. However, the three-point bending press cannot be used in the edge bending at both widthwise end portions of the steel plate 3. The three-point bending press cannot be performed because the end portion of the sheet plate 3 does not touch one of the lower dies. To this end, the edge bending is usually performed by pressing with a pair of upper and lower dies.

[0018] As illustrated in FIG. 1(c), the remaining half of the steel plate from the widthwise central line CL is subjected to plural times of three-point bending press 4 at equal distances (provided that the portion of the widthwise central line CL is retained unpressed), whereby the steel plate 3 is shaped into substantially a semicircular form. Finally, as illustrated in FIG. 1(d), both the widthwise end portions of the steel plate 3 are butted by performing three-point bending press 4 at the position of the widthwise central line CL and thereafter the seams are welded to form a non-expanded pipe 1 illustrated in FIG. 1(e).

[0019] In the thus obtained non-expanded pipe 1, there are arc-like deformation areas 8 (solid line portions) and flat non-deformation areas 9 (dotted line portions) as illustrated by section in FIG. 3. The deformation area 8 is a site subjected to deformation by a series of the above three-point bending press illustrated in FIG. 1 (or a site subjected to deformation by pressing the arc-like curved surface of the upper forming tool 6), and the non-deformation area 9 is a site not deformed by the three-point bending press.

[0020] Then, a pipe expander provided with a plurality of expander tools having curved surfaces of plural divided arcs is inserted into the inside of the non-expanded pipe and enlarged in radial direction to expand the non-expanded pipe to thereby form a steel pipe. As previously mentioned, the non-expanded pipe has the arc-like deformation areas and the flat non-deformation areas. Therefore, it is necessary to deform the flat non-deformation area into an arc form for enhancing the roundness of the steel pipe. However, since a gap exists between the adjoining expander tools in the pipe expander, the non-expanded pipe cannot be expanded in the circumferential direction uniformly.

[0021] In the present invention, therefore, when the pipe expanding is performed by inserting the pipe expander provided with the plural expander tools into the inside of the non-expanded pipe, the arc-like curved surfaces of the expander tools are pushed onto all of the non-deformation areas to expand the non-expanded pipe. Thus, the non-deformation areas are preferentially deformed while suppressing the deformation of the deformation area not contacting with the expander tool, whereby the non-deformation areas can form a continuous arc together with the deformation areas previously shaped into an arc form and hence the roundness of the steel pipe can be enhanced.

[0022] In order to deform the non-deformation areas into an arc form in a good roundness as mentioned above, it is preferable that the number of the non-deformation areas in the non-expanded pipe is the same as the number of the expander tools in the pipe expander inserted into the inside of the non-expanded pipe. That is, when the number of the expander tools is N, it is preferable to perform the three-point bending press so as to render the number of the non-deformation areas in the non-expanded pipe into N sites. In this case, one welded seam and (N-1) deformation areas are arranged in gaps of N expander tools. Also, the number of times of three-point bending press may be (N-1).

[0023] For instance, FIG. 3 illustrates a case that the number of the non-deformation areas 9 is coincident with the number of the expander tools 2, namely, a view showing an example of expanding the non-expanded pipe 1 subjected to three-point bending press of 11 times with twelve expander tools 2. As illustrated in FIG. 3, the number of times of three-point bending press 4 subjected to the raw steel plate for providing twelve non-deformation areas 9 may be 5 times of three-point bending press 4 subjected to one half of the plate divided by widthwise central line CL illustrated in FIG. 1(b), 5 times of three-point bending press 4 subjected to the other half of the plate divided by widthwise central line CL in FIG. 1(c), and 1 time of three-point bending press 4 subjected at the position of widthwise central line CL illustrated in FIG. 1(d) (11 times in total). This is because the non-deformation areas are 12 sites in total between deformation areas by three-point press bending (10 sites) and between edge bent portion and deformation area by three-point bending press (2 sites). Therefore, the pipe expanding may be performed by pushing the twelve expander tools onto all of the respective 12 non-deformation areas.

[0024] In the present invention, the number of the non-deformation areas in the non-expanded pipe may be an integral multiple of the number of expander tools in the pipe expander inserted into the inside of the non-expanded pipe such as 2 times, 3 times or the like. FIG. 4 illustrates a case that pipe expanding is performed by inserting a pipe expander with ten expander tools 2 into a non-expanded pipe 1 having twenty non-deformation areas 9 formed by three-point bending press of 19 times, namely, an example that the number of the non-deformation areas 9 is 2 times of the number of the expander tools 2. In this case, each of the expander tools can be pushed onto all of the non-deformation areas in such a manner that one expander tool is pushed onto the two adjacent non-deformation areas. As illustrated in FIG. 4, the number of times of three-point bending press required for forming 2N sites of non-deformation areas corresponding to 2 times of the number of expander tools N may be (2N - 1).

[0025] As mentioned above, when the number of the expander tools in the present invention is N, the number of times of three-point bending press is (aN - 1) (wherein a is an arbitrary integer such as 1, 2, or the like). FIG. 3 corresponds to an example of a = 1, and FIG. 4 corresponds to an example of a = 2. Even if a is 3 or more, each expander tool is pushed onto a sites of the non-deformation areas and then all of non-deformation areas can be pushed onto the expander tools.

[0026] In the present invention, the feed pitch of the steel plate in the three-point bending press is at equal distance, so that the width of the non-deformation area is same as the feed pitch in the press. The feed pitch P_p is represented by the following equation (1) when a distance of start position of three-point bending press from a center of plate width is W_0 and the press number is M:

$$P_p = 2W_0/(M-1) \dots (1)$$

[0027] Moreover, the W_0 is $(W/2 - (L + P_p/2))$ when the plate width of the raw steel plate is W and the width of edge bending is L. Therefore, the equation (1) is transformed into $P_p = (W - 2L)/M$. Also, when the number of the expander tools (division number of circumference) is N, the number of the sites not contacting with the expander tool is N, so that the interval of the non-deformation area P_d is represented by the following equation (2):

$$P_d = W/N \dots (2)$$

[0028] Therefore, in order to push all of the expander tools onto all of the non-deformation areas, it is enough to set the press number M and the width of edge bending L so that the value P_p is same as P_d or a value obtained by dividing P_d by integral multiple. In the setting of P_p , considering the width of the non-deformation area during three-point bending press, the whole region of the non-deformation areas may be pushed by the expander tools, and then the roundness can be more improved.

[0029] By using the production method according to the present invention as mentioned above, when the number of expander tools is N, the number of times of three-point bending press required for the production of large-diameter and thick-walled steel pipes can be reduced to (aN - 1) (wherein a is an integer of 1, 2 or the like), so that it is possible to largely improve the productivity of the steel pipes. Also, all steps from edge bending of the steel plate through three-point bending press to pipe expanding can be conducted as cold working, so that the steel pipes can be produced without damaging excellent properties inherent to the raw steel plate. Particularly, the effect of the present invention is remarkable in the production of thick-walled steel pipes having a thickness of 25.4~50.8 mm.

EXAMPLES

[0030] There are provided seven raw steel plates having a plate width W of 3713 mm (thickness: 25.4 mm, tensile strength: 745~757 MPa). Both widthwise end portions of the steel plate (width L: 215 mm) are subjected to edge bent with dies having a radius of curvature of 380 mm so as to render a bent angle after load removal (see FIG. 1(b)) into 16.9°. Then, the edge bent steel plate is shaped into a cylindrical form by subjecting to three-point bending press with an upper forming tool having a radius of curvature of 380 mm, and the seams are welded to form a non-expanded pipe. Thereafter, a pipe expander provided with plural expander tools each having a radius of curvature of 580 mm at a surface pushing onto an inner face of the non-expanded pipe is inserted into the inside of the non-expanded pipe and pipe expanding is performed at a pipe expanding ratio (= 100 x (diameter after pipe expanding - diameter before pipe expanding) / (diameter before pipe expanding)) of 1% to produce a steel pipe. Moreover, conditions of three-point bending press other than the above condition and conditions of pipe expanding are varied as shown in Tables 1 and 2.

[0031] In a steel pipe A (Invention Example), the raw steel plate is shaped into substantially a cylindrical form by subjecting to three-point bending press of 5 times with a starting point at a position of 1492 mm from a widthwise central line toward one side at a feed pitch P_p in a direction of widthwise central line of 298 mm, then subjecting to three-point bending press of 5 times with a starting point at a position of 1492 mm from a widthwise central line toward the other side at a feed pitch P_p in a direction of widthwise central line of 298 mm, and finally subjecting to three-point bending press of 1 time at a position of widthwise central line (11 times in total), and thereafter widthwise end seams of the steel plate are welded to each other to form a non-expanded pipe having 12 non-deformation areas. Moreover, a bent angle after load removal in three-point bending press (see FIG. 2(b)) is 29.6°.

[0032] Thereafter, a pipe expander provided with 12 expander tools in a circumferential direction is inserted into the inside of the non-expanded pipe and the expander tool is pushed onto the respective non-deformation area and the welded portion is disposed in the gap between the expander tools to perform pipe expanding as illustrated in FIG. 1,

whereby a steel pipe is produced. Incidentally, a face of the expander tool contacting with an inner face of the non-expanded pipe is an arc having a radius of curvature of 580 mm and an angle of 27.7° (the same applies hereafter when the number of expander tools is 12).

[0033] A steel pipe B (Invention Example) is an example of producing a steel pipe by manufacturing a non-expanded pipe having 10 non-deformation areas under conditions shown in Table 1, inserting a pipe expander provided with 10 expander tools in a circumferential direction into the inside of the non-expanded pipe, pushing the expander tool onto the respective non-deformation area and disposing the welded portion of the non-expanded pipe in the gap between the expander tools to perform pipe expanding as the steel pipe A. Incidentally, an opening angle (circular arc angle) of an arc of the expander tool contacting with the inner face of the non-expanded pipe and having a radius of curvature of 580 mm is 33.4° (the same applies hereafter when the number of expander tools is 10).

[0034] A steel pipe C (Invention Example) is an example of producing a steel pipe by performing three-point bending press of 19 times to manufacture a non-expanded pipe having 20 non-deformation areas as shown in Table 1, inserting a pipe expander provided with 10 expander tools in a circumferential direction into the inside of the non-expanded pipe, and pushing one expander tool onto the two non-deformation areas as shown in Table 2 to perform pipe expanding.

[0035] On the other hand, a steel pipe D (Comparative Example) is an example of producing a steel pipe by inserting a pipe expander provided with 12 expander tools as in the steel pipe A into an inside of a non-expanded pipe produced under the same conditions as in the steel pipe A and having 12 non-deformation areas and pushing each of the expander tools onto the deformation area as as to place the non-deformation area in the gap between the expander tools as illustrated in FIG. 5 to perform pipe expanding.

[0036] Also, a steel pipe E (Comparative Example) is an example of producing a steel pipe by inserting the same pipe expander provided with 10 expander tools as in the steel pipe B into an inside of a non-expanded pipe produced under the same conditions as in the steel pipe B and having 10 non-deformation areas and pushing each of the expander tools onto the deformation area as as to place the non-deformation area in the gap between the expander tools as illustrated in FIG. 5 to perform pipe expanding.

[0037] Further, a steel pipe F (Comparative Example) and a steel pipe G (Comparative Example) are examples of producing a steel pipe by manufacturing a non-expanded pipe having 8 or 10 non-deformation areas under conditions shown in Table 1, inserting a pipe expander provided with expander tools different from the number of non-deformation areas into the inside of the non-expanded pipe as shown in Table 2 and then performing pipe expanding at a state of not contacting the expander tool with a part of the non-deformation areas. As a reference, FIG. 6 shows a case of the steel pipe G.

[0038] With respect to the thus obtained steel pipes A~G are measured the roundness and productivity of the steel pipe to obtain results also shown in Table 2. Moreover, the roundness is evaluated by measuring a difference m between an outer surface of a steel pipe 11 and virtual true circle 10 as illustrated in FIG. 7 with a dial gauge at a distance of 150 mm in a circumferential direction to determine a maximum value $m_{\max}$ of the difference m in each steel pipe and calculating a ratio of $m_{\max}$ of each steel pipe to $m_{\max}$ of the steel pipe D (hereinafter referred to as "difference index (ratio)"). The difference index of the steel pipe D is 1.00, and as the difference m becomes near to zero, the steel pipe becomes near to true circle. That is, the smaller the difference index becomes, the better the roundness of the steel pipe becomes. Furthermore, the productivity is evaluated by a time required from a start of the first three-point bending press to the end of the last three-point bending press.

Table 1

Steel pipe	Conditions for three-point bending press				
	Press number N (times)	Start position W_0 (mm)	Feed pitch P_P (mm)	Bentangle ($^\circ$)	Time required (sec/one pipe)
A	11	1492	298	29.6	269
B	9	1459	365	36.1	246
C	19	1555	173	17.1	391
D	11	1492	298	29.6	270
E	9	1459	365	36.1	246
F	7	1407	469	46.5	245
G	11	1492	298	29.6	303

Table 2

Steel pipe	Number of times of three-point bending press (times)	Conditions for pipe expanding			Difference index	Remarks
		Number of expander tools N	Number of non-deformation areas	Contact between expander tool with non-deformation area		
A	11	12	12	present	0.65	Invention Example
B	9	10	10	present	0.66	
C	19	10	20	present	0.62	
D	11	12	12	<u>absent</u>	1.00	Comparative Example
E	9	10	10	<u>absent</u>	1.13	
F	7	10	8	<u>partially absent</u>	1.14	
G	11	10	12	<u>partially absent</u>	0.93	

[0039] As seen from Table 2, the difference index in the steel pipes A~C of Invention Examples is 0.62~0.66, while the difference index in the steel pipes D~G of Comparative Examples is 0.93~1.14, so that the roundness is excellent in the steel pipes of Invention Examples as compared to the steel pipes of Comparative Examples.

[0040] Also, the roundness of the steel pipes A and B having the small number of times of three-point bending press in Invention Examples is slightly poor as compared with that of the steel pipe C having a large number of times of three-point bending press, but the pressing time is shortened by not less than 30% as shown in Table 1, from which it can be seen that the steel pipes having a good roundness can be produced in a high productivity by applying the present invention.

INDUSTRIAL APPLICABILITY

[0041] The production method of steel pipes according to the present invention is not limited to the production of large-diameter and thick-walled steel pipes, and can be applied to all of methods of producing steel pipes by performing three-point bending press.

DESCRIPTION OF REFERENCE SYMBOLS

[0042]

- 1: non-expanded pipe
- 2: expander tool
- 3: steel plate
- 4: three-point bending press
- 5a. 5b: lower die
- 6: upper forming tool
- 7: welded portion
- 8: deformation area
- 9: non-deformation area
- 10: virtual true circle
- 11: steel pipe

Claims

1. A method of producing a steel pipe by shaping a steel plate subjected to edge bending into a cylindrical form through plural times of three-point bending press in widthwise direction and welding seams thereof to form a non-expanded pipe, inserting a pipe expander provided with plural expander tools into an inside of the non-expanded pipe to perform pipe expanding, **characterized in that** the expander tools are pushed onto all sites of non-deformation areas in three-point bending press to perform pipe expanding.

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2. The method of producing a steel pipe according to claim 1, **characterized in that** the number of times of the three-point press bending is $(aN - 1)$ wherein a is an integer of 1, 2 or the like when the number of the expander tools is N .

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FIG. 1

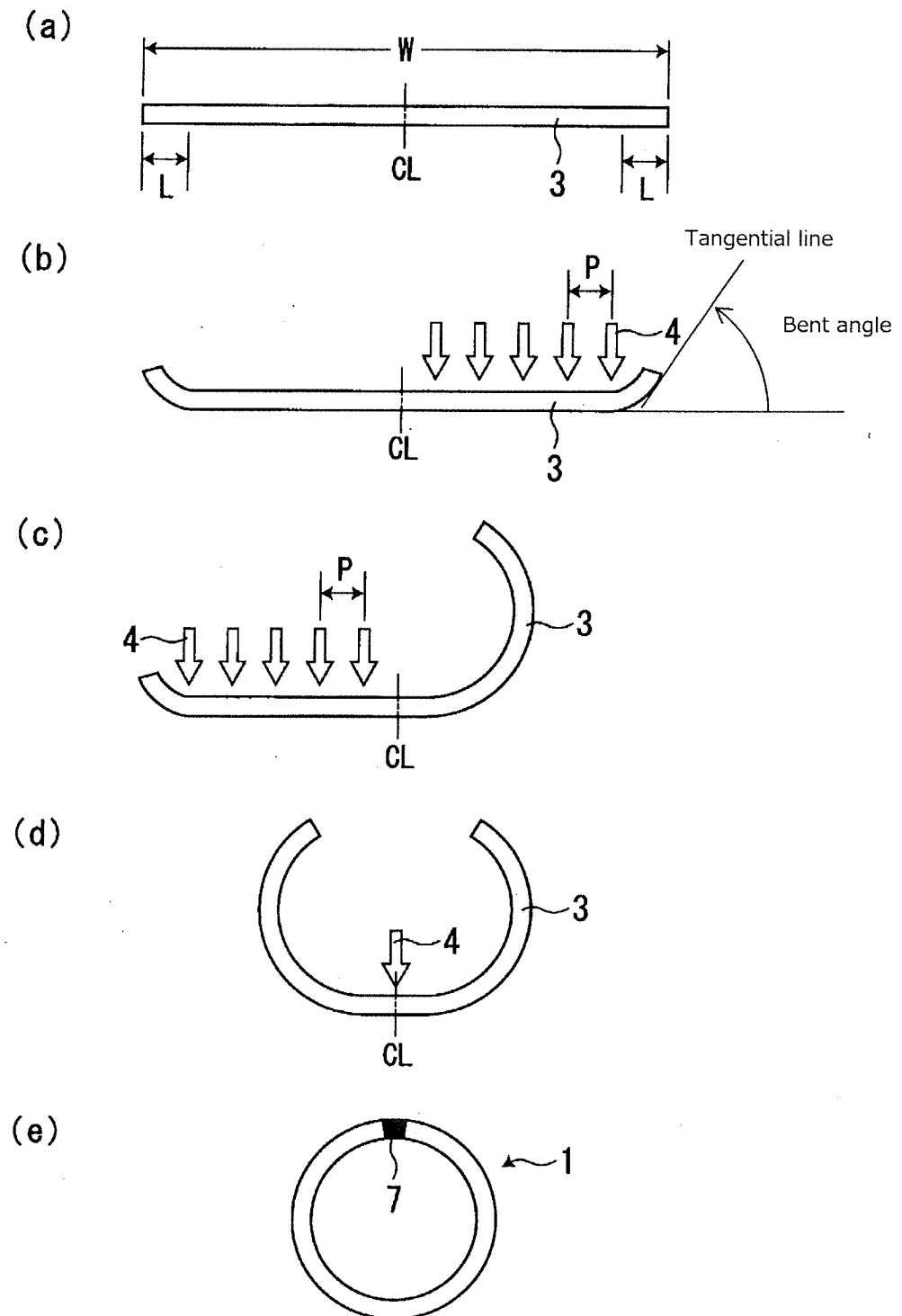
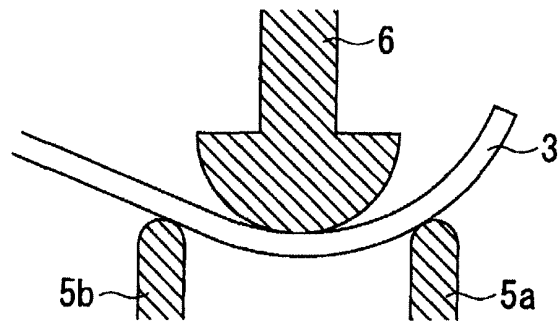


FIG. 2

(a)



(b)

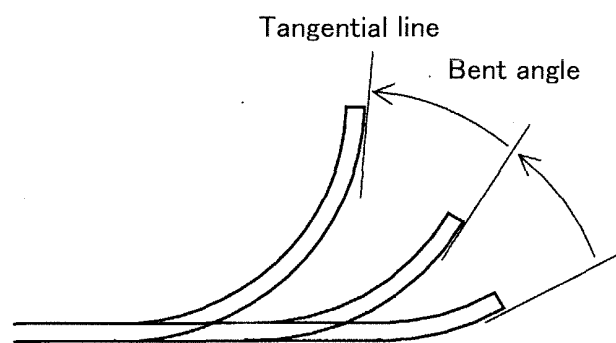


FIG. 3

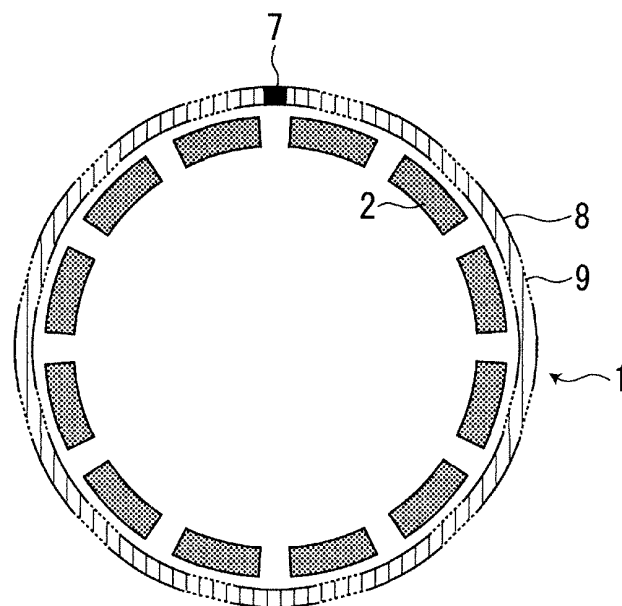


FIG. 4

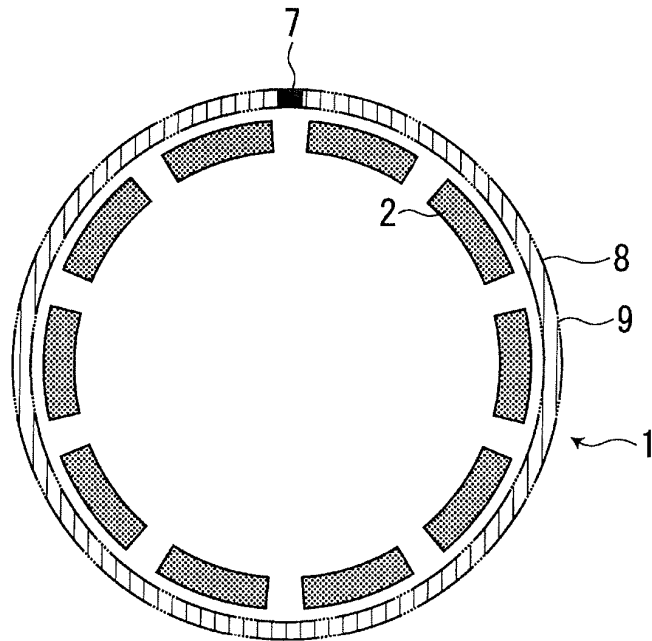


FIG. 5

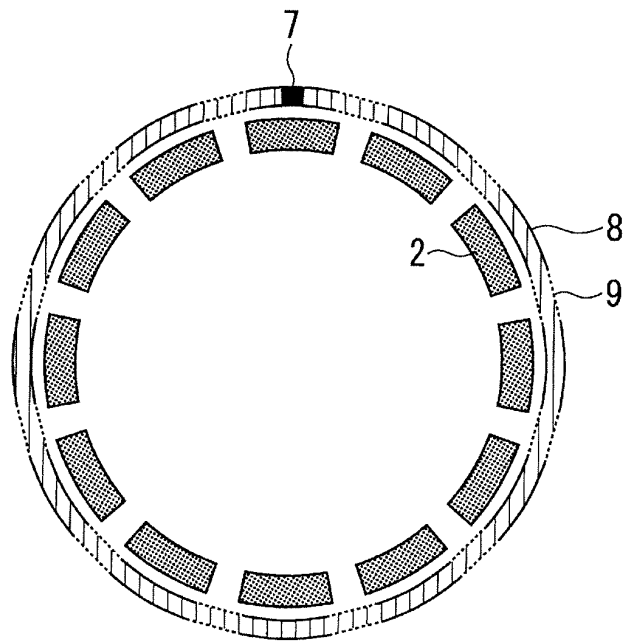


FIG. 6

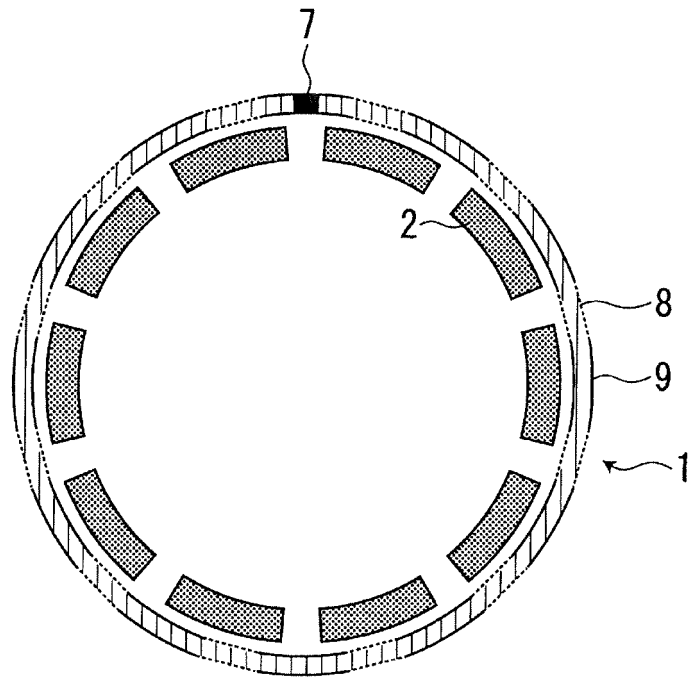
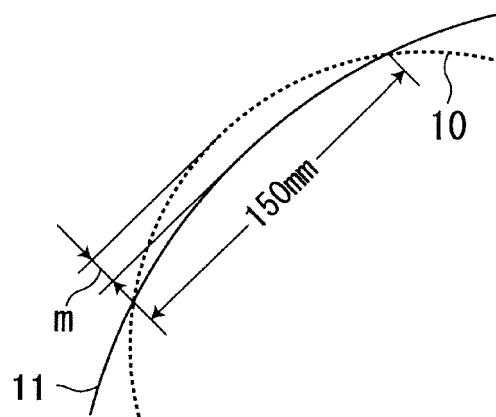


FIG. 7



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/070321

A. CLASSIFICATION OF SUBJECT MATTER

B21D5/01(2006.01) i, B21D39/20(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)

B21D5/01, B21D39/20

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 1996-2012

Kokai Jitsuyo Shinan Koho 1971-2012 Toroku Jitsuyo Shinan Koho 1994-2012

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.
Y	JP 2004-82219 A (SMS Meer GmbH), 18 March 2004 (18.03.2004), paragraphs [0002] to [0007] & US 2004/0055356 A1 & EP 1382402 A2 & DE 10232098 A & DE 50305093 D & AT 340039 T	1-2
Y	JP 2011-132601 A (JFE Steel Corp.), 07 July 2011 (07.07.2011), paragraph [0063] & WO 2011/065578 A1	1-2
Y	JP 2011-206800 A (Kobe Steel, Ltd.), 20 October 2011 (20.10.2011), fig. 2 (Family: none)	1-2

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

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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 8-300069 A (NKK Corp.), 19 November 1996 (19.11.1996), paragraphs [0009] to [0013] (Family: none)	1-2
Y	JP 9-24433 A (NKK Corp.), 28 January 1997 (28.01.1997), paragraphs [0014] to [0015]; fig. 3 to 4 (Family: none)	1-2

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2005324255 A [0006]