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

(11) EP 3 127 625 A1

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

(43) Date of publication:
08.02.2017 Bulletin 2017/06

(21) Application number: **15773059.9**

(22) Date of filing: **30.03.2015**

(51) Int Cl.:
B21D 5/01 *(2006.01)* ***B21C 37/08*** *(2006.01)*

(86) International application number:
PCT/JP2015/059835

(87) International publication number:
WO 2015/152108 (08.10.2015 Gazette 2015/40)

(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: **31.03.2014 JP 2014070703**
09.03.2015 JP 2015046083

(71) Applicant: **JFE Steel Corporation**
Tokyo, 100-0011 (JP)

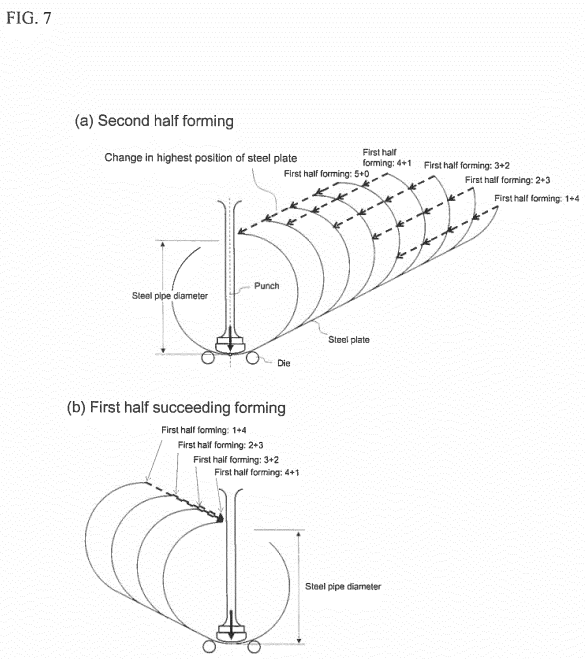
(72) Inventors:
- **HORIE Masayuki**
  Tokyo 100-0011 (JP)
- **TAMURA Yukuya**
  Tokyo 100-0011 (JP)
- **MIWA Toshihiro**
  Tokyo 100-0011 (JP)
- **NISHIMURA Tomomi**
  Akashi-shi
  Hyogo 674-0093 (JP)
- **USHIO Tomizo**
  Akashi-shi
  Hyogo 674-0093 (JP)
- **TANIICHI Kenji**
  Akashi-shi
  Hyogo 674-0093 (JP)

(74) Representative: **Grünecker Patent- und Rechtsanwälte**
PartG mbB
Leopoldstraße 4
80802 München (DE)

(54) STEEL-PIPE SHAPING METHOD AND SHAPING DEVICE USING THREE-POINT BENDING

(57) Provided is a method for forming a steel pipe for forming a steel plate as raw material into a substantially cylindrical shape, by first half forming performing three-point bending-press a plurality of times from one plate width end portion of the steel plate as raw material toward a plate width center, second half forming performing three-point bending-press a plurality of times from the other plate width end portion toward the plate width center, and final forming performing the three-point bending-press on the plate width central portion, wherein the first half forming is divided into preceding forming performed before the second half forming and succeeding forming performed after the second half forming, and a ratio of a forming range in the preceding forming to the steel plate width is set in a range of more than 0.17 to less than 0.46. Thus, a producible maximum diameter of the steel pipe is enlarged without modifying the equipment of the existing pressing machine.

FIG. 7



EP 3 127 625 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a method for forming a steel pipe used for a line pipe or the like, and particularly, to a method and an apparatus for forming a steel pipe by performing three-point bending-press forming a plurality of times in a steel plate as raw material.

RELATED ART

[0002] As a steel pipe used for a line pipe or the like, a steel pipe having high roundness formed by press-forming a steel plate as raw material having a predetermined width, length and thickness into a U-shape, press-forming it into an O-shape, welding a butted part to make a steel pipe as raw material, and enlarging (so-called pipe expanding) the diameter of the pipe, i.e., a so-called UOE steel pipe has been widely used. In recent years, however, as the steel pipe used for a line pipe or the like, a heavy wall-thickness steel pipe having high strength and a large diameter has been used. Since there is a need for great press force to press-form the steel plate into a U-shape and an O-shape in a method for producing the UOE steel pipe, a producing range has been limited or productivity has significantly decreased in the conventional producing equipment.

[0003] Therefore, as a method capable of reducing the press force in the production of the heavy wall-thickness steel pipe having high strength and a large diameter, a press-bending type steel pipe producing method has been put into practical use which comprises applying bending (so-called edge bending) to both width end portions of the steel plate, forming the steel plate into a substantially cylindrical shape by multiple bending-press, welding the butted part, expanding the pipe for correcting the shape to form a steel pipe.

[0004] There has been proposed some methods for the press-bending type steel pipe producing technique. For example, Patent Document 1 discloses a method wherein one plate width end portion is pressed as a preceding stage, the plate width central portion is pressed, the other plate width end portion is pressed as a succeeding stage, and then the plate width central portion is pressed. Also, Patent Document 2 discloses a method comprising performing the three steps press-forming from the one width end portion of the steel plate toward the width center, significantly moving the steel plate to the other side, performing the three steps press-forming from the other end portion toward the center, forming the steel plate in a shape similar to a round shape while leaving the central portion, and performing the press-forming on the remaining central portion. Moreover, Patent Document 3 discloses a method of obtaining the semi-finished pipe products by sequentially repeating the process of performing the bending forming by three-points of the upper and lower dies, feeding the plate material in the width direction by a constant rate feeding device, and applying the bending to a position different from the position formed earlier.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0005]

Patent Document 1: JP-A-2005-324255
Patent Document 2: JP-A-2007-090406
Patent Document 3: JP-A-2011-056524

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0006] Each of the methods disclosed in Patent Documents 1-3 adopts a method of forming the one half of the steel plate as raw material into a substantially semicircular shape by performing a bending-press from one plate width end portion of the steel plate as raw material toward the center while leaving the last portion to be bending-pressed and performing the bending-press forming from the other plate width end portion. In this method, however, when starting the bending-press forming from the other plate width end portion, the one half portion previously formed in a substantially semicircular shape is largely lifted, and its height may reach about 1.5 times the product steel pipe size (outer diameter).

[0007] In such a case, when the size of the pressing machine is relatively smaller compared to the outer diameter of the steel pipe subjected to the bending-press forming, or when there is no room for space available for producing the steel pipe due to auxiliary equipment or the like installed on the pressing machine, the lifted portion of the preformed

steel plate may interfere with the pressing machine or its auxiliary equipment, whereby equipment damage may be caused or the producible maximum outer diameter size may be substantially restricted. To cope with such problems, there is need to devise a design which prevents the steel plate from contacting with the pressing machine by increasing the height of the pressing machine or changing the mounting position of the auxiliary equipment. Further, when it is necessary to renew the equipment, significant capital investment will be needed.

[0008] The invention has been made in view of the above problems inherent to the conventional techniques, and is to propose a method for forming a steel pipe enable to expand the producible maximum diameter of the steel pipe, without modifying the existing pressing machine in the production of a steel pipe through a three-point bending-press method (press-bending method).

MEANS FOR SOLVING PROBLEMS

[0009] In order to solve the above problems, the inventors have carried out extensive studies while paying attention to changes in the steel plate shape in the course of forming depending on the forming order of the steel pipe. As a result, it has been found out that it is possible to reduce the lifting height of the preformed portion, by dividing the bending-press forming (first half forming) carried out from one plate width end portion of the steel plate as raw material toward the center in the conventional technique into two parts of preceding forming and succeeding forming and also by setting the forming range in the preceding forming in a proper range, whereby the maximum diameter of producible steel pipe can be enlarged, and the invention has been accomplished

[0010] That is, the invention is a method for forming a steel pipe for forming a steel plate as raw material into a substantially cylindrical shape, by first half forming which performs three-point bending-press a plurality of times from one plate width end portion of the steel plate as raw material toward the plate width center, second half forming which performs the three-point bending-press a plurality of times from the other plate width end portion toward the plate width center, and final forming which performs the three-point bending-press on the plate width central portion, wherein the first half forming is divided into preceding forming performed before the second half forming and a succeeding forming performed after the second half forming, and the ratio of the forming range in the preceding forming to the steel plate width is set in a range of more than 0.17 to less than 0.46.

[0011] The method of forming the steel pipe according to the invention is characterized in that a ratio of the forming range in the preceding forming of the first half forming to the steel plate width is set in a range of 0.21 to 0.42.

[0012] Further, the method of forming the steel pipe according to the invention is characterized in that the steel plate as raw material is applied with edge bending to both end portions of the plate width.

[0013] Furthermore, the invention provides a forming apparatus of a steel pipe used in the any one of the above forming method of the steel pipe, characterized in that a distance between a top portion of a punch supporter and a top portion of a lower die when the punch is lowered to the lowest position during press is not more than 1.4 times of the outer diameter of the steel pipe to be produced.

EFFECTS OF THE INVENTION

[0014] According to the invention, since it is possible to keep the highest reaching position to which the steel plate is lifted during the press-forming to a lower level, the producible maximum outer diameter of the steel pipe can be enlarged without making an improvement to the existing pressing machine.

[0015] Further, according to the invention, since it is possible to keep the highest reaching position to which the steel plate is lifted during the press-forming to a lower level, there are merits such that it is possible to restrain the height of the pressing machine used for forming or to enhance the flexibility of design, and in addition, it is possible to reduce the capital investment, such as being able to lower the height of the building to install a pressing machine or to reduce the depth to dig into the floor.

[0016] Further, according to the invention, since the highest reaching position to which the steel plate is lifted is kept low and the falling amount of the steel plate is reduced at the time of releasing the press force after each of the bending-press, the impact force at the time of falling of the steel plate is reduced, so that effects such as prevention of steel plate defect, prevention of the damage of pressing machine, reduction in impact noise and the like can be expected.

BRIEF DESCRIPTION OF DRAWINGS

[0017]

FIG. 1 is a schematic view illustrating a method of forming a steel pipe by a press-bending method.

FIGs. 2(a) and 2(b) are schematic views illustrating changes in a steel plate shape of each press in a conventional press-bending method.

FIGs. 3(a) and 3(b) are schematic views illustrating changes in the steel plate shape when the five press-forming in first half forming is performed by being divided into a preceding one time and succeeding four times.

FIGs. 4(a) and 4(b) are schematic views illustrating changes in the steel plate shape when the five press-forming in the first half forming is performed by being divided into preceding two times and succeeding three times.

FIGs. 5(a) and 5(b) are schematic views illustrating changes in the steel plate shape when the five press-forming in the first half forming is performed by being divided into preceding three times and succeeding two times.

FIGs. 6(a) and 6(b) are schematic views illustrating changes in the steel plate shape when the five press-forming in the first half forming is performed by being divided into preceding four times and succeeding one time.

FIGs. 7(a) and 7(b) are schematic views collectively illustrating changes in highest height position to which the steel plate is lifted in the course of forming shown in FIGs. 2 to 6.

FIGs. 8(a) and 8(b) are schematic views illustrating a relation among a distance of an elevation guide, a position of an upper structure and a steel plate shape.

FIG. 9 is a graph showing a relation between a bending range in the first half preceding forming and a maximum height of the width end of the steel plate.

FIGs. 10(a) and 10(b) are schematic views illustrating whether the steel plate enters an entry prohibited region in the forming method of an example.

EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0018] FIG. 1 schematically shows a forming method of a steel pipe through a press-bending method, and a direction perpendicular to a paper surface corresponds to a longitudinal direction of the steel plate as raw material, that is, a longitudinal direction of the steel pipe. The steel pipe is formed by repeatedly performing the process of setting a steel plate as a material on a pair of lower dies disposed so as to be spaced apart from each other, performing the bending-press of the steel plate by lowering a punch by a driving device not shown, lifting the punch, feeding the steel plate in a plate width direction using a feeding device not shown, and thereafter, performing the next bending-press. In addition, the punch has a punch head which contacts with the steel plate, and a punch supporter that connects the punch head and the driving device. The punch head and the punch supporter may be directly connected to each other or may be connected to each other via a spacer therebetween. The width of the punch supporter may be equal to the width of the punch head but is preferably smaller than the width of the punch head.

[0019] First, as the first half forming, bending-press and steel plate feeding are repeated a plurality of times (a times) from the plate width end portion of the steel plate as raw material toward the plate width center (from the portion A toward the portion C in FIG. 1), and one side half of the steel plate as raw material (except the plate width central portion C of the steel plate) is formed into a substantially semicircular shape. In the present invention, this forming process is hereinafter referred to as "first half forming". Also, FIG. 1 shows an example of using a steel plate applied with edge bending to both width end portions of the steel plate as raw material. It is preferable to apply the edge bending from the viewpoint of suppressing the seam welded part from having an acute angle and improving the roundness, but it may not be applied. In the case of applying the edge bending, a crimping press method disclosed in JP-A-H08-294727, JP-A-S51-76158 or the like can be suitably used.

[0020] Next, the bending-press and the steel plate feeding are repeated a plurality of times (b times) from the other plate width end portion of the steel plate as raw material toward the plate width center (from the portion B toward the portion C in FIG. 1), and the one side half of the steel plate as raw material (except the plate width central portion C of the steel plate) is formed into a substantially semicircular shape. In the present invention, this forming process is hereinafter referred to as "second half forming". At this time, in order to have the same shape as the substantially semicircular portion formed in the first half forming, the forming conditions such as the press times a, b, the bending angle and the steel plate feed length and the like are generally the same as those of the first half forming.

[0021] A material to be formed (steel plate) subjected to the first half forming and the second half forming has a shape such as a capital letter C of alphabet in which a flat portion remains in a portion of the plate width central portion C and the butted parts of both side end portions of the steel plate are open. Finally, the flat portion C of the plate width central portion is subjected to a single bending-press, and the distance between the butted parts is made slightly wider than the width of the punch supporter. In the present invention, this forming process is hereinafter referred to as "final forming". Thereafter, the formed steel plate is moved in the longitudinal direction and transferred to the outside of the pressing machine, the formed opening portion is pressed, closed and welded, and thereafter the pipe is expanded to make a product steel pipe.

[0022] FIGs. 2(a) and 2(b) show changes in steel plate shape of each press forming step associated with the progress of the press by a solid line and a dotted line, when both the press times a, b in the first half forming and the second half forming are five times in the forming method of the steel pipe by the conventional press-bending method shown in FIG. 1. Further, an arrow shown by a dashed line indicates a change in highest position of the lifted steel plate at each press.

[0023] It can be seen from the figures that in the first half forming shown in FIG. 2(a), the highest position to which the

steel plate is lifted is not so high, but in the second half forming shown in FIG. 2(b), the steel plate is lifted to the highest position in the first press forming of the second half forming, and the height becomes lower as the forming progresses, but the steel plate position sequentially gets closer to the pressing machine body, which may cause a risk of contact.

[0024] In general, in the pressing machine used in forming the steel pipe, forming force is loaded to the material to be formed (steel plate) from above through the punch by a cylinder mechanism installed on the top portion of the pressing machine, and a driving mechanism such as a hydraulic cylinder, a hydraulic pump and a hydraulic tank or the like is installed as auxiliary equipment on the top portion of the pressing machine having the punch. However, the forming force required for forming the steel pipe is increased as strength of the steel plate becomes higher and the thickness of the plate becomes larger. Further, the size of the auxiliary equipment is also increased proportionately. Therefore, in the pressing machine for producing a heavy wall-thickness steel pipe with high strength, the auxiliary equipment such as a driving mechanism disposed on the top portion of the pressing machine is inevitably increased to be liable to interfere with the steel plate. In the press of each time, when the punch is lowered to the lowest position, the driving device connected at the upper end portion of the punch supporter is also lowered to the lowest position, and at the same time, the lifting of the steel plate becomes maximum. Accordingly, even when the punch is lowered to the lowest position, it is important to prevent the steel plate from interfering with the driving mechanism disposed on the top portion of the pressing machine.

[0025] Therefore, the inventors have studied the relation among the press forming sequence, the shape of steel plate and the lifting height of the cases when the first half forming is divided into two parts of a preceding forming and a succeeding forming, when both the press times a, b in the first half forming and the second half forming are five times.

[0026] FIGs. 3(a) and 3(b) illustrate changes in steel plate shapes of each press of the first half succeeding forming and the second half forming and changes in highest height position to which the steel plate is lifted, when one press is performed in the preceding forming of the first half forming, five presses are performed in the second half forming, and then remaining four presses are performed in the first half succeeding forming. FIGs. 4(a) and 4(b) illustrate such changes when two presses are performed in the preceding forming of the first half, five presses are performed in the second half forming, and then remaining three presses are performed in the first half succeeding forming. FIGs. 5(a) and 5(b) show such changes when three presses are performed in the preceding forming of the first half, the five presses are performed in the second half forming, and then remaining two presses are performed in the first half succeeding forming. FIGs. 6(a) and 6(b) illustrate such changes when four presses are performed in the preceding forming of the first half, the five presses are performed in the second half forming, and then remaining one press is performed in the first half succeeding forming. Here, in each drawing, (a) shows changes in the steel plate shape and changes in highest height position to which the steel plate is lifted in the second half forming, and (b) illustrates such changes in the first half succeeding forming. Further, since the first half preceding forming is the same as FIG. 2(a), the description thereof is not provided. Also, in each drawing, the solid line and the dotted line represent changes in steel plate shape, and the dashed arrow represents the highest height position to which the steel plate is lifted. For example, each of the solid lines of FIGs. 3(a), 4(a), 5(a) and 6(a) indicates a steel plate shape when performing the first press of the second half forming. Further, each of the solid lines of FIGs. 3(b), 4(b), 5(b) and 6(b) indicates the steel plate shape when performing the first press of the succeeding forming of the first half forming.

[0027] It can be seen from FIGs. 2(a) to 6(b) that the highest height position to which the steel plate is lifted varies by changing the number of pressings in the first half preceding forming. Therefore, drawings obtained by gathering changes in the highest height position to which the steel plate is lifted in FIGs. 2(a) to 6(b) in one drawing is FIGs. 7(a) and 7(b). FIG. 7(a) represents the second half forming, and FIG. 7(b) illustrates the first half succeeding forming.

[0028] It can be seen from Fig. 7(a) that the steel plate is lifted to the highest position in the press of the second half forming, when the presses are performed four times in the first half preceding forming and one time in the first half succeeding forming (indicated by first half forming: 4 + 1), then, when the presses are performed three times in the first half preceding forming and two times in the first half succeeding forming (indicated by first half forming: 3 + 2), then, when the presses are performed five times at a time without dividing the first half forming into two parts (indicated by first half forming: 5 + 0), and then, when the presses are performed two times in the first half preceding forming and three times in the first half succeeding forming (indicated by first half forming: 2 + 3) and further, the steel plate is lifted to the lowest position when the presses are performed one time in the first half preceding forming and four times in the first half succeeding forming (indicated by first half forming 1 + 4).

[0029] In each case of the first half forming: 4 + 1, the first half forming: 3 + 2 and the first half forming: 2 + 3, the highest height position to which the steel plate is lifted is almost the same level as that of the case of the first half forming: 5 + 0. However, in the case of the first half forming: 4 + 1, since the highest height position of the steel plate is closest to the pressing machine, there is a high risk of interference of the material to be formed (steel plate) with the pressing machine and the auxiliary equipment. Thus, in the second half forming, it is in the case of the first half forming: 3 + 2, the first half forming: 2 + 3 and the first half forming: 1 + 4 that there is low risk of interference of the forming target material (steel plate) with the pressing machine.

[0030] Also, it can be seen from FIG. 7(b) that in the press of the first half succeeding forming, the steel plate is lifted

to the highest position in the case of the first half forming: 1 + 4 wherein the lifting height of the steel plate is the lowest in FIG. 7(a), then, the case of the first half forming: 2 + 3, and then, the case of first half forming: 3 + 2, and further, the lifting height of the steel plate is the lowest in the case of the first half forming: 4 + 1, and as the number of pressings in the preceding forming becomes lower, the lifting height becomes higher.

[0031] Thus, when taking FIGs. 7(a) and 7(b) together, it is considered that there is the lowest risk of contact between the material to be formed with the pressing machine in the case of forming a steel pipe using the press-bending method, when the presses are performed three times in the first half preceding forming and two times in the first half succeeding forming (first half forming: 3 + 2), when the presses are performed two times in the first half preceding forming and three times in the first half succeeding forming (first half forming: 2 + 3) and when the presses are performed four times in the preceding forming and one time in the first half succeeding forming (first half forming: 4 + 1).

[0032] Thus, in the press-forming of the present invention, it is preferable to perform the press a plurality of times in the first half forming by being divided into the preceding forming and the succeeding forming, thereby optimizing the number of pressings in the preceding forming. However, the number of pressings is a matter which can be arbitrarily set. In the present invention, therefore, the preferable press conditions are defined as a range in which bending deformation occurs by the press in the first half preceding forming (hereinafter, referred to as "preceding forming range").

[0033] The steel plate having a substantially cylindrical shape after the final press-forming is transferred to the outside of the pressing machine by moving the steel plate having the substantially cylindrical shape in its longitudinal direction. In this case, a distance between pillars (also referred to as "elevation guide") that support the upper structure of the pressing machine is required to be sufficiently wider than the width of the forming body of substantially cylindrical shape. In FIGs. 8(a) and 8(b) is illustrated the elevation guide distance, the position of the upper structure and the steel plate shape when the distance of the elevation guide is 1.4 times the outer diameter of the product steel pipe + 300 mm (maximum opening width of seam) so as to form a steel pipe having an outer diameter of 1219.2 mm. FIG. 9 shows a relation between the maximum height of the width end of the steel plate and the preceding forming range at this time. When the first half preceding forming is performed not more than three times, in the second half forming of (preceding forming range/ steel plate width of not more than 0.3), the steel plate does not interfere with the upper structure as is clear from FIG. 8(a), so that its plot is omitted. Further, the preceding forming range is represented by the ratio to the steel plate width, and the maximum height of the width end of the steel plate is represented by the ratio to the outer diameter of the product steel pipe, since the absolute values of the dimensions of the forming range and the maximum height of the width end of the steel plate differ depending on the outer diameter of the steel pipe to be manufactured.

[0034] Here, points of mark ● in FIG. 9 are the maximum heights of the width end of the steel plate of the preceding forming portion when performing second half forming and correspond to the width end of steel plate in FIG. 8(a). The point at which the ratio of the preceding forming range to the steel plate width is 0.46 is a case of performing the forming without dividing the first half forming into the preceding and succeeding stages (first half forming in FIG. 8(a): 5 + 0), and the maximum height reaches 1.4 times the outer diameter of the product steel pipe. However, as the ratio of the preceding forming range to the steel plate width becomes smaller than 0.46, the maximum height becomes smaller. Thus, the ratio of the preceding forming range to the steel plate width is required to be less than 0.46, and is preferably not more than 0.42. If the ratio is not more than 0.38, the maximum height can be restrained by not less than 10%, as compared to the case of not dividing the first half forming into the preceding and succeeding stages, so that the range is more preferable.

[0035] Meanwhile, points of mark 0 in FIG. 9 are the maximum heights of the width end of the plate of the second half forming portion when performing the first half succeeding forming, and correspond to the position of width end of the plate in FIG. 8(b). As the ratio of the preceding forming range to the steel plate width is increased, the maximum height is decreased. When the ratio of the preceding forming range to the steel plate width exceeds 0.17, the maximum height is decreased as compared to the points of the second half forming in the case of forming without dividing the first half forming into the preceding and succeeding stages, that is, in the case where the ratio of the preceding forming range to the steel plate width is 0.46. Thus, the ratio of the preceding forming range to the steel plate width is required to exceed 0.17 and is preferably not less than 0.21. If the ratio is not less than 0.29, the maximum height can be restrained by not less than 10% as compared to the case of not dividing the first half forming into the preceding and succeeding stages, so that the range is more preferable.

[0036] Moreover, in the description as described above, a case wherein the three-point bending-press is performed five times in the first half forming, five times in the second half forming, and one time in the final forming (total 11 times) has been described as an example, but in the method for producing the steel pipe according to the invention, the number of pressings is not limited to 11 but may be increased or decreased. However, when decreasing the number of pressings, the bending angle per each time is increased, and accordingly the lifting height of the steel plate is increased, and roundness after forming is also degraded. On the other hand, when increasing the number of pressings, the lifting height of the steel plate is decreased and the roundness after forming also becomes higher, but productivity is lowered. Therefore, it is preferable to determine the number of pressings in consideration of advantages and disadvantages thereof.

[0037] Furthermore, in the above description, from the viewpoint of making the steel plate shape after the first half

forming and the steel plate shape after the second half forming in the same shape as mentioned above, the number of pressings in the first half forming and the second half forming and the feed length of the steel plate are the same, but may be changed as long as the roundness can be secured.

EXAMPLES

[0038] An experiment of producing a steel pipe having an outer diameter: 1422.4 mm × length: 12.8 m × pipe thickness: 12.7 mm is conducted from a heavy wall-thickness steel plate (strength: X100) applied with edge bending of 17 degrees to 210 mm range of both width end portions of the plate width: 4428 mm by the bending-press method using a pressing machine having capability of 100 MN.

[0039] Here, in the bending-pressing machine used in the above experiment, the steel plate widthwise dimension of the driving device which connects to the upper end portion of the punch supporter is 2300 mm (one side 1150 mm from the center on the punch). Further, in this pressing machine, the distance between the lowest surface of the driving device connected to the punch supporter upper end portion and the lower die upper surface when the punch is lowered to the lowest position in the press-forming is 1890 mm.

[0040] Further, as the press method using the bending-press machine, a method is adopted wherein the press is performed five times from the position of 1822 mm from the plate width center toward the plate width center both in the first half forming and the second half forming, and the width central portion is finally formed (total 11 times), and the feed length of steel plate in each press was set to 364 mm, and the bending angle is set to 29.5 degrees.

[0041] Further, as illustrated in Table 1, the press of the first half forming is performed five times for four kinds of forming methods (A to D) wherein the forming is divided into two parts of the preceding forming and the succeeding forming, after performing a predetermined number of press within five times in the first half preceding forming, the press of the second half forming is performed five times, and thereafter the remaining press is performed in the first half succeeding forming, and a conventional forming method E of instantly performing the press of the first half forming five times as a reference example.

[0042] Moreover, as illustrated in FIGs. 10(a) and 10(b), each of the forming methods is evaluated by the degree of entry of the steel plate to a region which causes the contact between the pressing machine and its auxiliary equipment when the material to be formed (steel plate) enters the top of the punch installation portion of the pressing machine.

[Table 1]

Press sign	Press conditions				Press result		Remarks
	Number of pressings			Bending range (ratio to steel plate width)	Whether steel plate enters entry prohibited region	Evaluation	
	First half preceding forming	Second half forming	first half succeeding forming				
A	1	5	4	574mm (0.13)	Heavy entry in first press of first half succeeding forming	×	Comparative Example
B	2	5	3	938mm (0.21)	Medium entry in first press of first half succeeding forming	Δ	Invention Example
C	3	5	2	1302mm (0.29)	No entry	○	Invention Example
D	4	5	1	1666mm (0.38)	Slight entry in fourth press of second half forming	Δ	Invention Example
E	5	5	0	2030mm (0.46)	Heavy entry in second press of second half forming	×	Comparative Example

[0043] The results of forming the steel pipe by the five press methods A to E are also shown in Table 1. The "bending range" shown in Table 1 is a distance from the plate end portion (also including edge bending portion) of the press-formed part in the first half preceding forming, and the numbers in parentheses show the ratio of the portion to the steel plate width. Also, changes in the highest position to which the steel plate is lifted in the above-described conditions are shown in FIGs. 10(a) and 10(b) together with the entry prohibited region of the steel plate.

[0044] As shown in Table 1 and FIGs. 10(a) and 10(b), in the case of the conventional method (method E) of forming to 0.46 in the ratio to the steel plate width in the first half forming, the steel plate largely enters the entry prohibited region in the second press of the second half forming, and there is a risk of damage to the pressing machine. Similarly, in the case of method A (first half forming: 1 + 4) of forming to 0.13 in the ratio to the steel plate width in the first half preceding forming, the steel plate largely enters the entry prohibited region in the first press of the first half succeeding forming (the second press of the first half forming), and there is also a risk of damage to the pressing machine.

[0045] In contrast, in the case of method B (first half forming: 2 + 3) of forming to 0.21 in the ratio to the steel plate width in the first half preceding forming, the steel plate moderately enters the entry prohibited region in the first press of the first half succeeding forming (the third press of the first half forming). Further, in the case of method D (first half forming: 4 + 1) of forming to 0.41 in the ratio to the steel plate width in the first half preceding forming, the steel plate slightly enters the entry prohibited region in the fourth press of the second half forming, but this is in a range where plastic deformation does not occur in the material to be formed (steel plate), which does not impair the product shape and does not damage the pressing machine.

[0046] Furthermore, in the case of method C (first half forming: 3 + 2) of forming to 0.29 in the ratio to the steel plate width in the first half preceding forming, the steel plate does not enter the entry prohibited region in each of the presses.

INDUSTRIAL APPLICABILITY

[0047] In this way, it can be seen that it is possible to avoid the material to be formed (steel plate) from coming into contact with the pressing machine or from being damaged by dividing the first half forming into the preceding and succeeding stages, and by setting the forming range of the preceding stage to a proper range. Therefore, by applying the present invention, it is possible to enlarge the producible maximum diameter of the pressing machine. In addition, as long as a steel pipe having a small outer diameter is used, it is needless to say that there is no need to apply the present invention and the steel pipe can be sufficiently formed by a conventional method.

Claims

1. A method for forming a steel pipe, forming a steel plate as raw material into a substantially cylindrical shape by first half forming performing three-point bending-press a plurality of times from one plate width end portion of the steel plate as raw material toward a plate width center, second half forming performing three-point bending-press a plurality of times from the other plate width end portion toward the plate width center, and final forming performing the three-point bending-press on the plate width central portion,
   characterized in that the first half forming is divided into preceding forming performed before the second half forming and succeeding forming performed after the second half forming, and a ratio of a forming range in the preceding forming to the steel plate width is set in a range of more than 0.17 to less than 0.46.

2. The method for forming a steel pipe according to claim 1, wherein a ratio of the forming range in the preceding forming of the first half forming to the steel plate width is set in a range of 0.21 to 0.42.

3. The method for forming a steel pipe according to claim 1 or 2, wherein the steel plate as raw material is made by applying edge bending to both end portions of the plate width.

4. An apparatus for forming a steel pipe used in the method for forming the steel pipe according to any of claims 1 to 3, wherein a distance between a top portion of a punch supporter and a lower die top portion when the punch is lowered to the lowest position during press is not more than 1.4 times of the outer diameter of the steel pipe to be produced.

FIG. 1

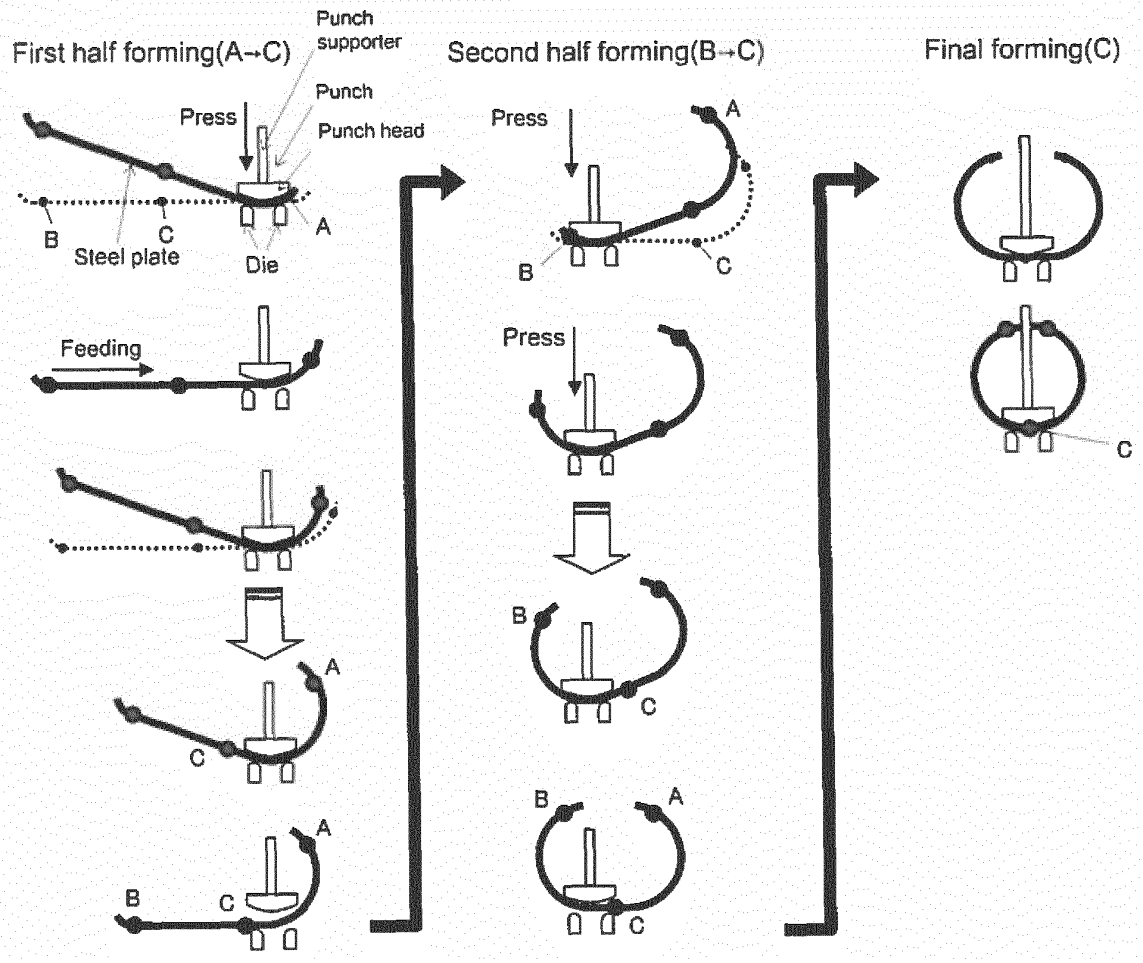

First half forming(A→C)
Punch supporter
Punch
Punch head
Press
B
C
A
Steel plate
Die
Feeding
C
A
B
C
A
Second half forming(B→C)
Press
A
B
C
Press
B
C
B
A
C
Final forming(C)
C

FIG. 2

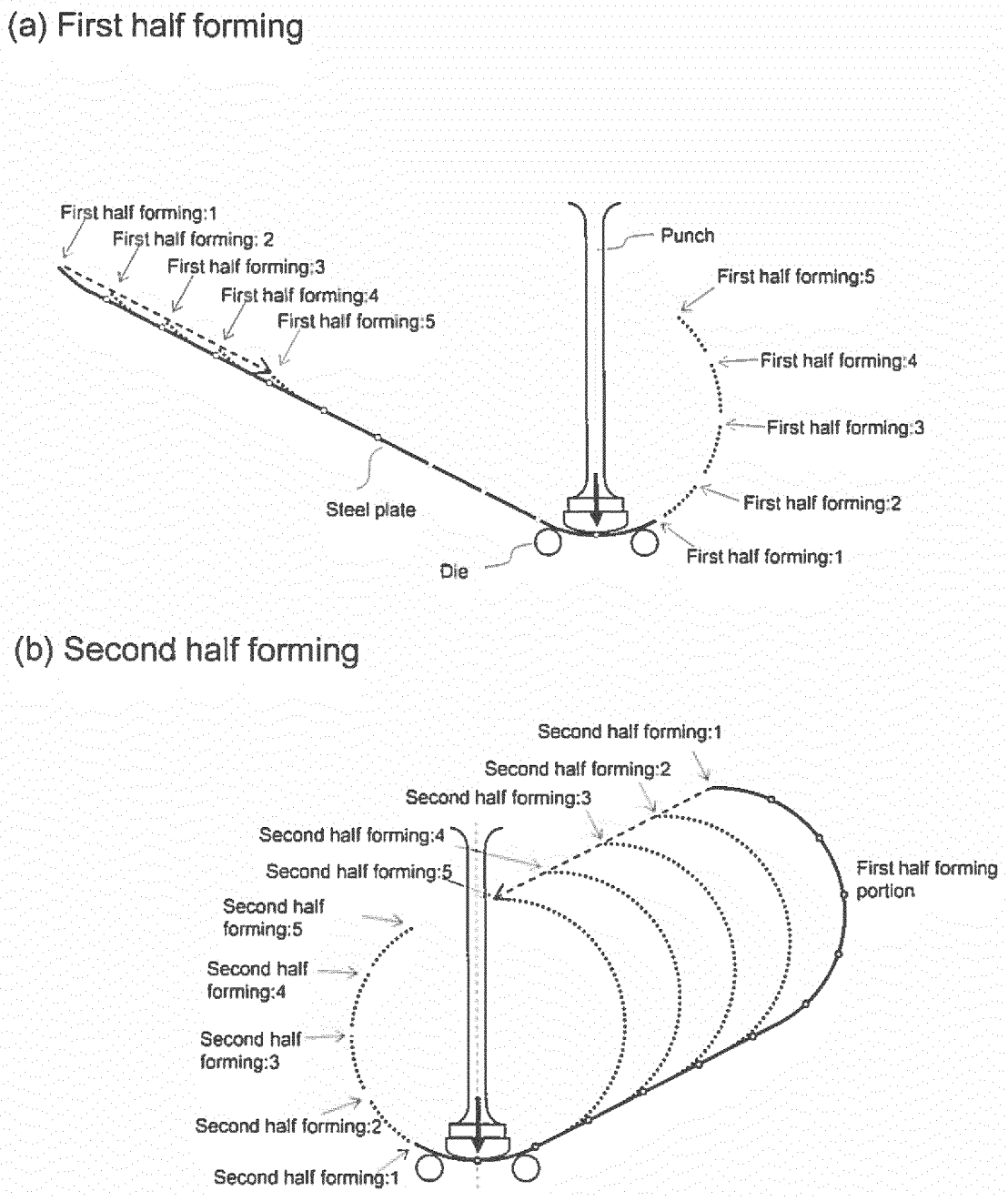

(a) First half forming
First half forming:1
First half forming: 2
First half forming:3
First half forming:4
First half forming:5
Punch
First half forming:5
First half forming:4
First half forming:3
First half forming:2
First half forming:1
Steel plate
Die
(b) Second half forming
Second half forming:1
Second half forming:2
Second half forming:3
Second half forming:4
Second half forming:5
First half forming portion
Second half forming:5
Second half forming:4
Second half forming:3
Second half forming:2
Second half forming:1

FIG. 3

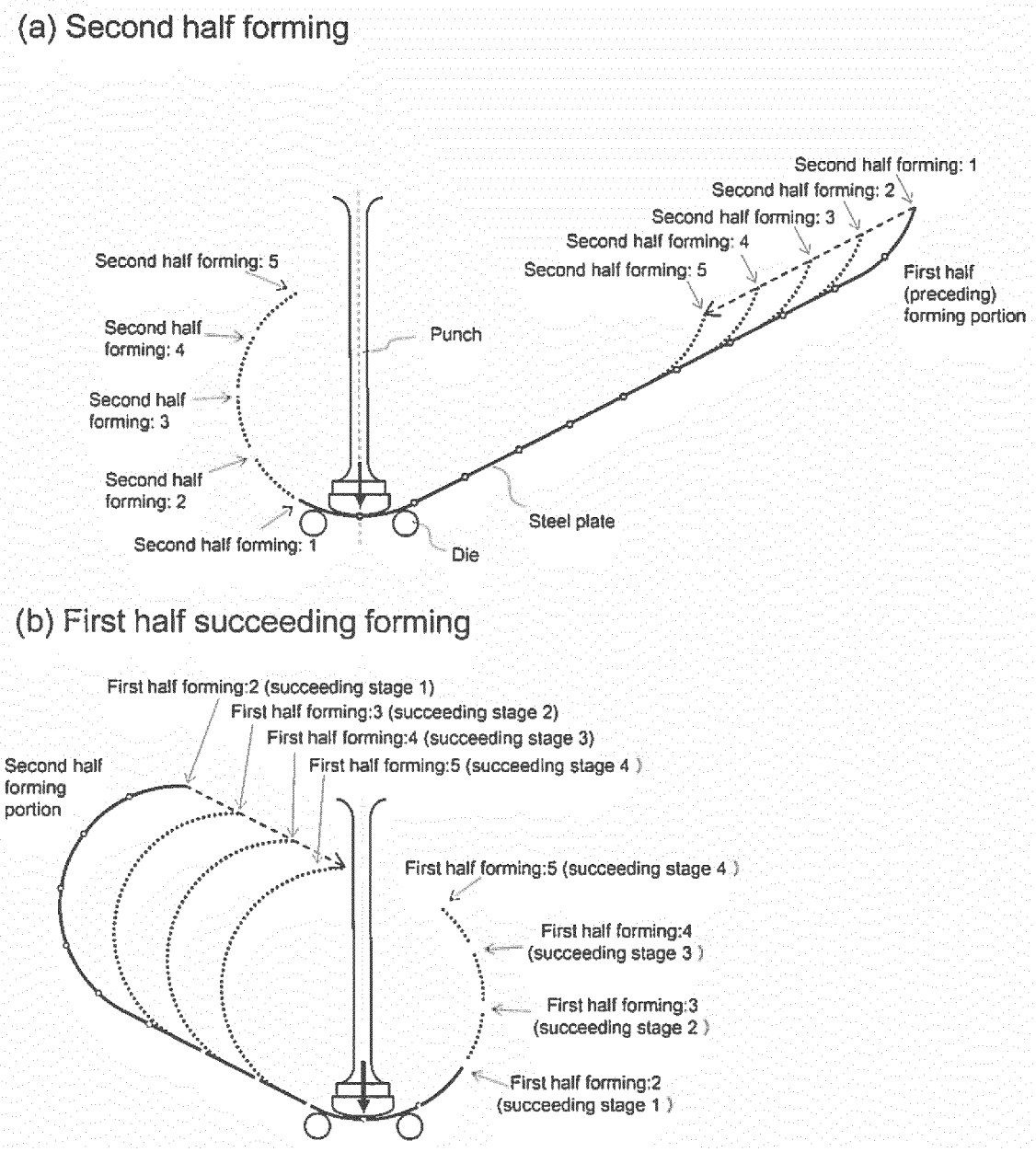

(a) Second half forming
Second half forming: 1
Second half forming: 2
Second half forming: 3
Second half forming: 4
Second half forming: 5
First half (preceding) forming portion
Second half forming: 5
Second half forming: 4
Second half forming: 3
Second half forming: 2
Second half forming: 1
Punch
Steel plate
Die
(b) First half succeeding forming
First half forming:2 (succeeding stage 1)
First half forming:3 (succeeding stage 2)
First half forming:4 (succeeding stage 3)
First half forming:5 (succeeding stage 4)
Second half forming portion
First half forming:5 (succeeding stage 4)
First half forming:4 (succeeding stage 3)
First half forming:3 (succeeding stage 2)
First half forming:2 (succeeding stage 1)

FIG. 4

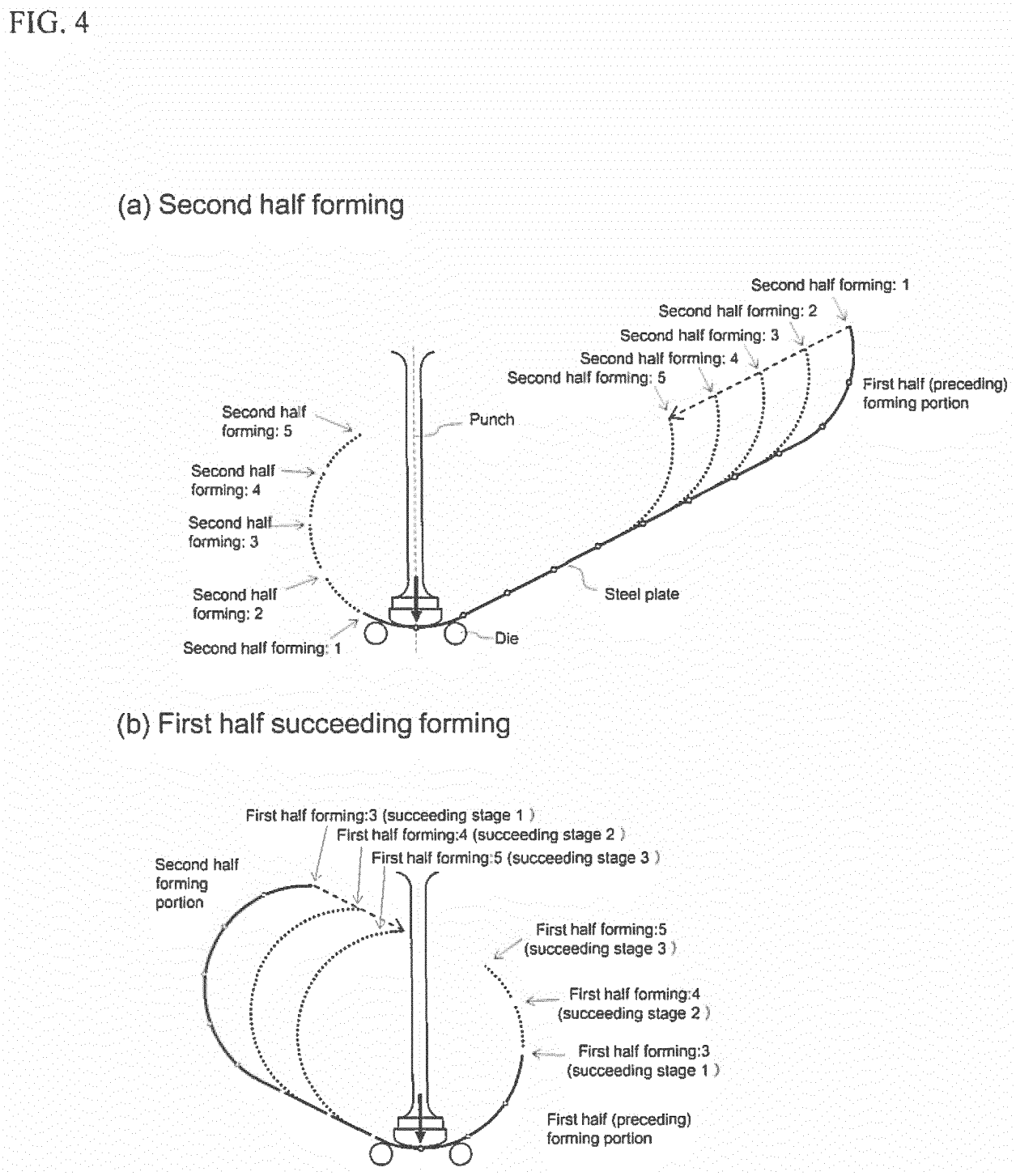

(a) Second half forming
Second half forming: 1
Second half forming: 2
Second half forming: 3
Second half forming: 4
Second half forming: 5
First half (preceding) forming portion
Second half forming: 5
Punch
Second half forming: 4
Second half forming: 3
Second half forming: 2
Steel plate
Second half forming: 1
Die
(b) First half succeeding forming
First half forming:3 (succeeding stage 1)
First half forming:4 (succeeding stage 2)
First half forming:5 (succeeding stage 3)
Second half forming portion
First half forming:5 (succeeding stage 3)
First half forming:4 (succeeding stage 2)
First half forming:3 (succeeding stage 1)
First half (preceding) forming portion

FIG. 5

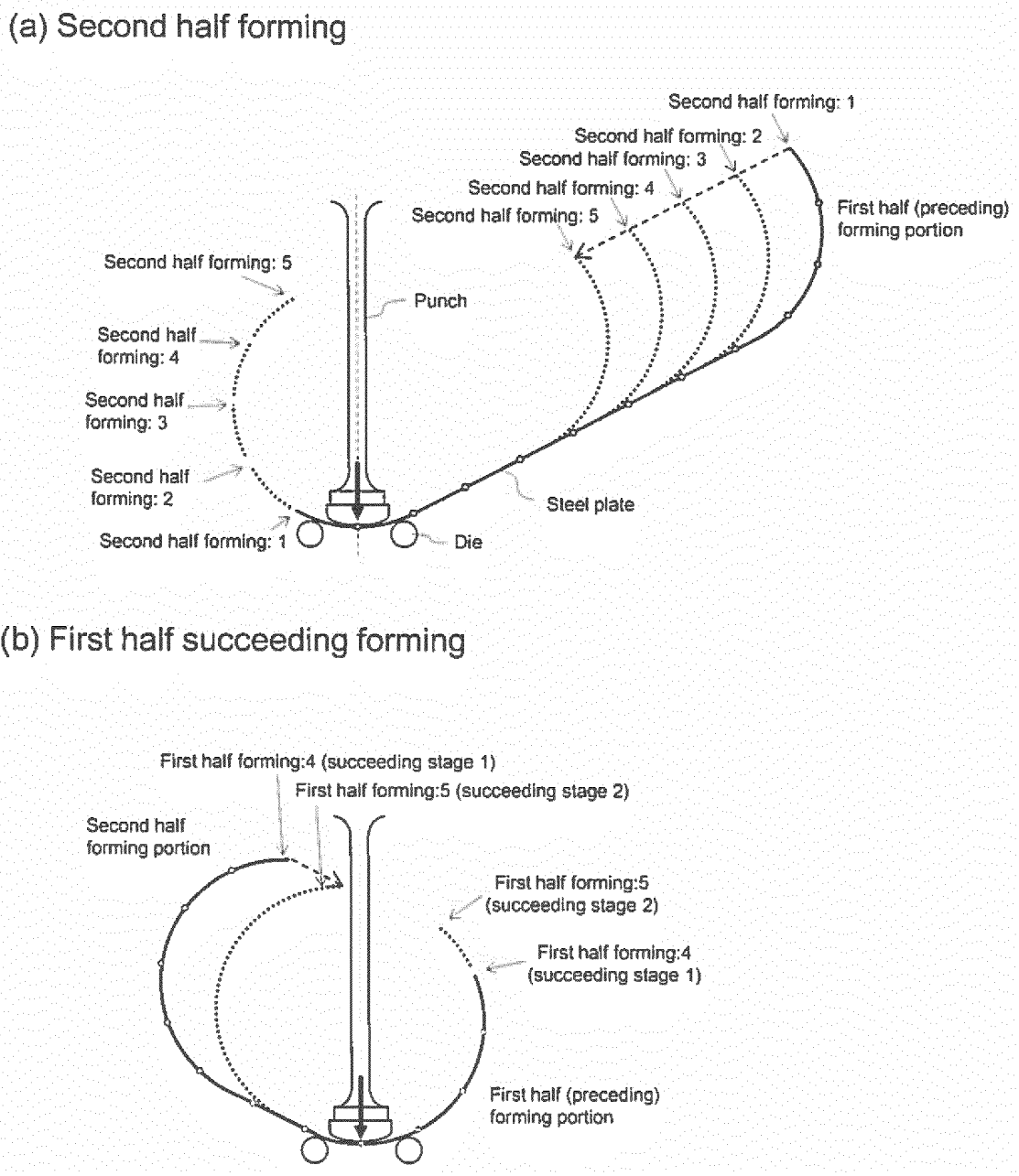
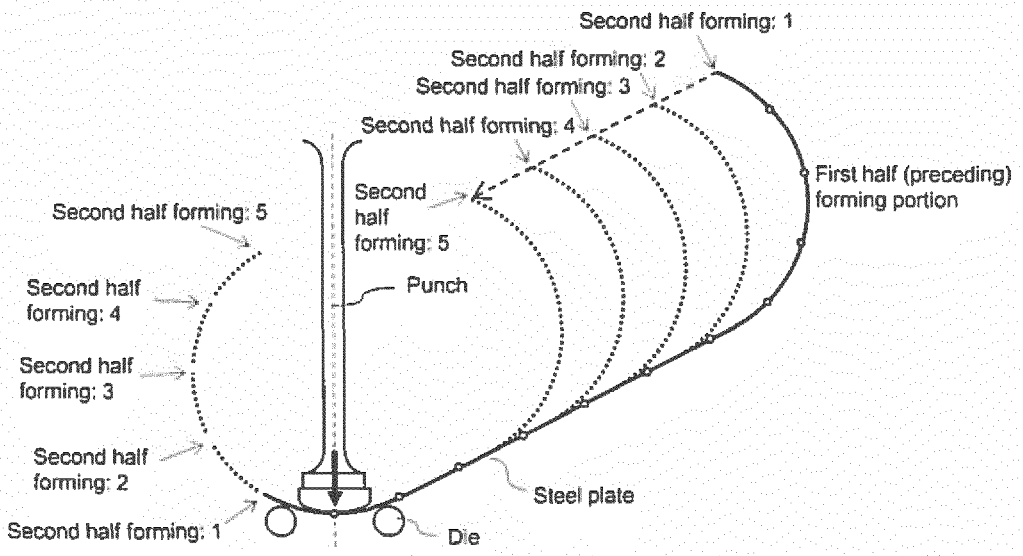

(a) Second half forming
Second half forming: 1
Second half forming: 2
Second half forming: 3
Second half forming: 4
Second half forming: 5
First half (preceding) forming portion
Second half forming: 5
Punch
Second half forming: 4
Second half forming: 3
Second half forming: 2
Second half forming: 1
Steel plate
Die
(b) First half succeeding forming
First half forming:4 (succeeding stage 1)
First half forming:5 (succeeding stage 2)
Second half forming portion
First half forming:5 (succeeding stage 2)
First half forming:4 (succeeding stage 1)
First half (preceding) forming portion

FIG. 6

(a) Second half forming



(b) First half succeeding forming

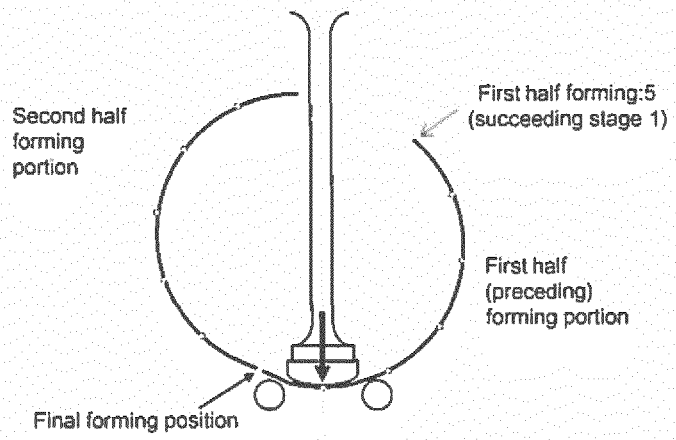


FIG. 7

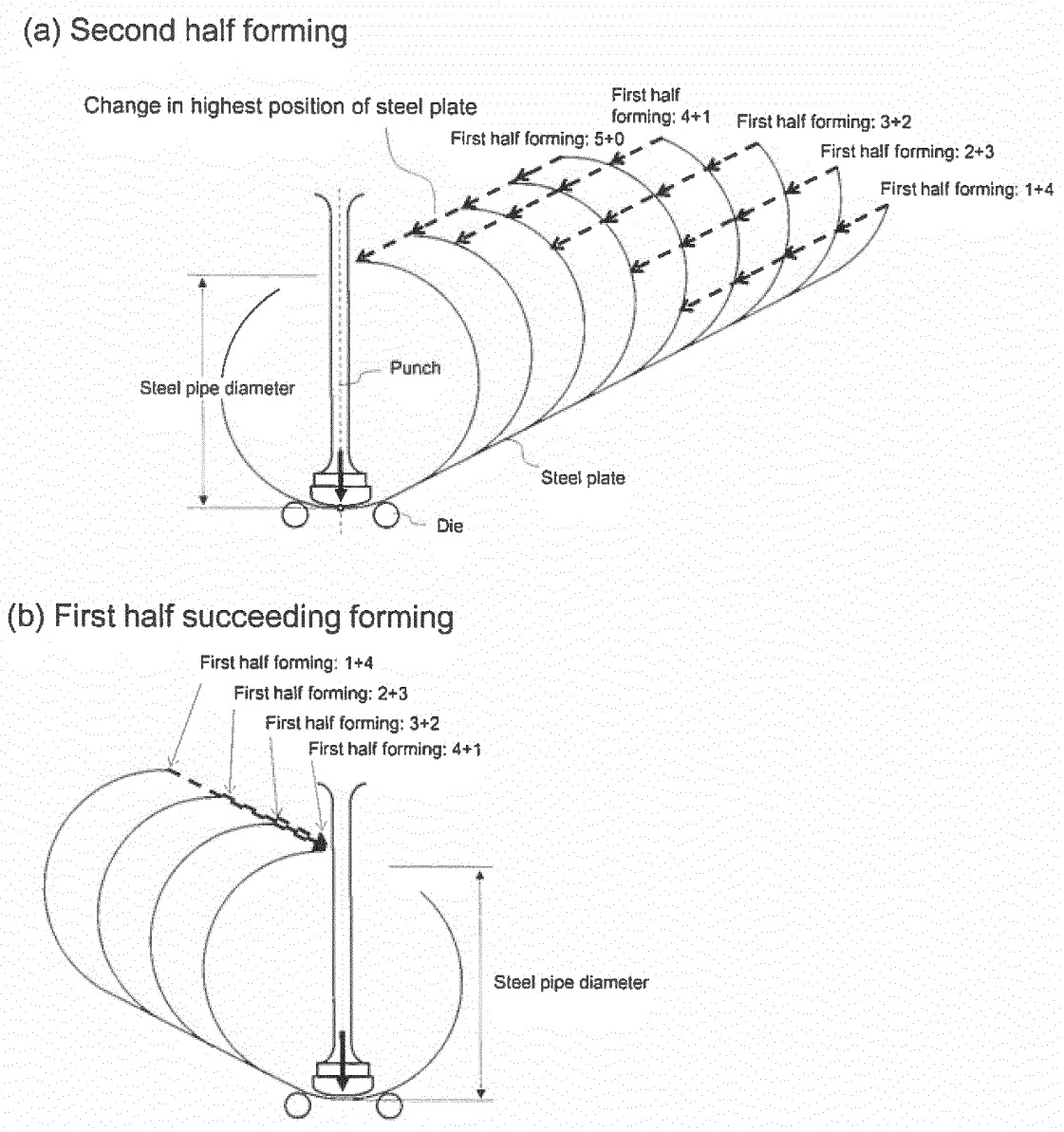

(a) Second half forming
Change in highest position of steel plate
First half forming: 4+1
First half forming: 3+2
First half forming: 5+0
First half forming: 2+3
First half forming: 1+4
Steel pipe diameter
Punch
Steel plate
Die
(b) First half succeeding forming
First half forming: 1+4
First half forming: 2+3
First half forming: 3+2
First half forming: 4+1
Steel pipe diameter

FIG. 8

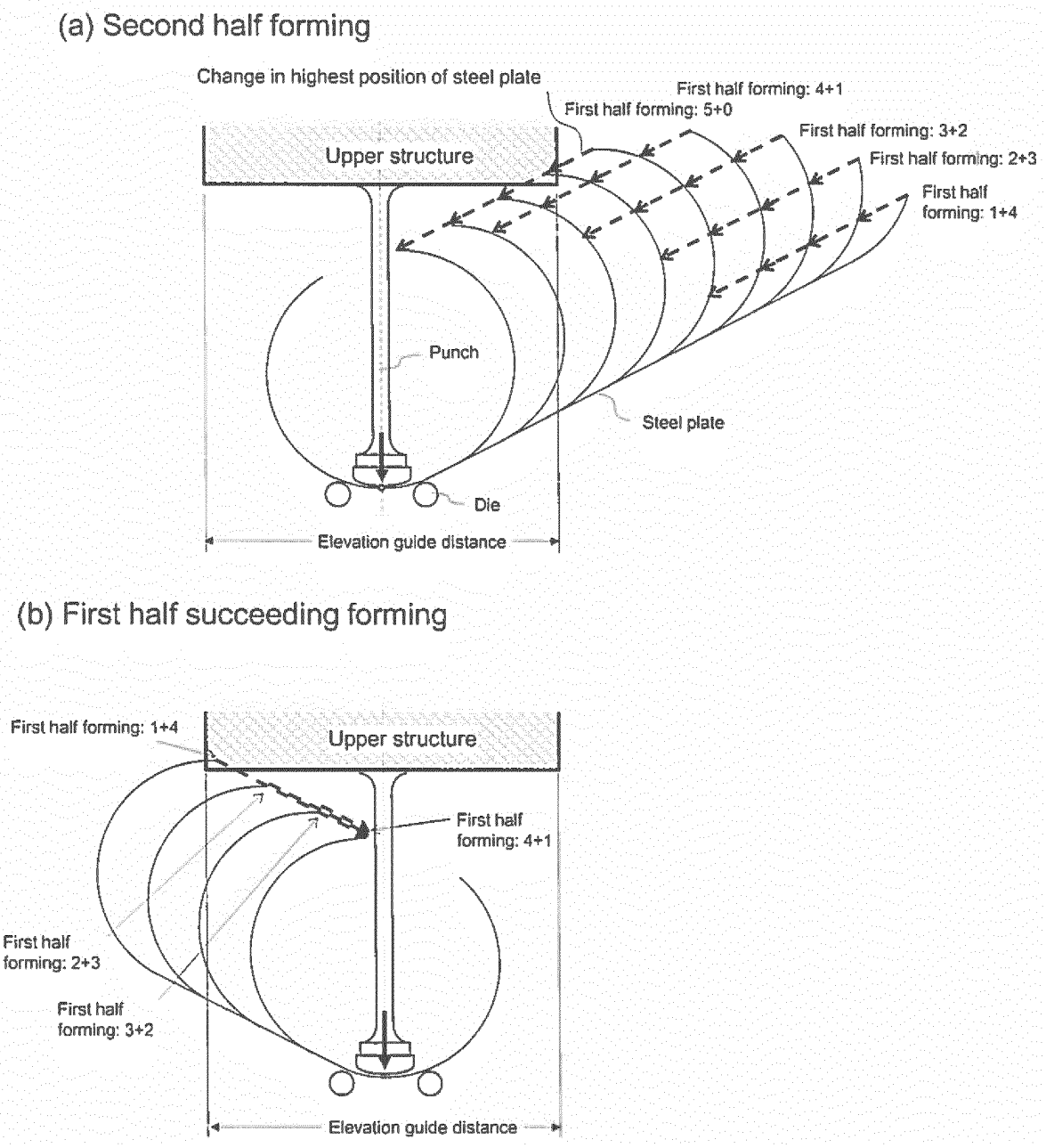

(a) Second half forming
Change in highest position of steel plate
First half forming: 4+1
First half forming: 5+0
First half forming: 3+2
First half forming: 2+3
First half forming: 1+4
Upper structure
Punch
Steel plate
Die
Elevation guide distance
(b) First half succeeding forming
First half forming: 1+4
Upper structure
First half forming: 4+1
First half forming: 2+3
First half forming: 3+2
Elevation guide distance

FIG. 9

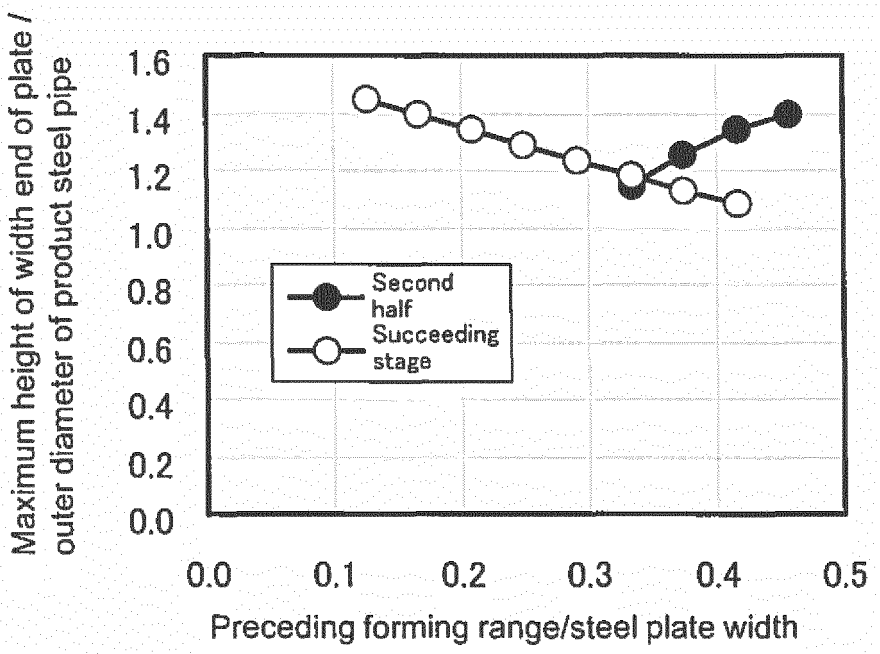
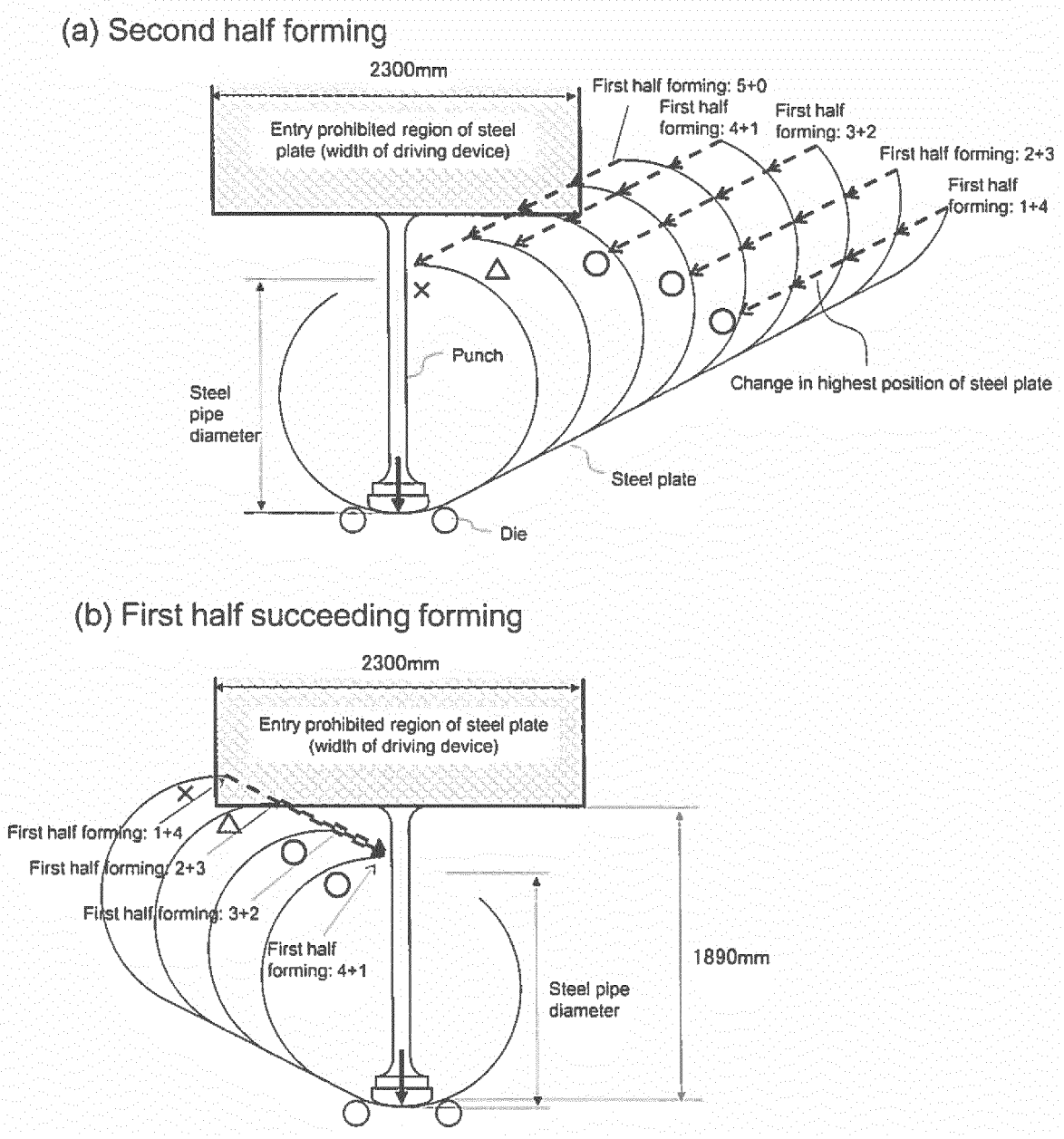

Maximum height of width end of plate / outer diameter of product steel pipe
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Second half
Succeeding stage
0.0
0.1
0.2
0.3
0.4
0.5
Preceding forming range/steel plate width

FIG. 10


(a) Second half forming
2300mm
Entry prohibited region of steel plate (width of driving device)
First half forming: 5+0
First half forming: 4+1
First half forming: 3+2
First half forming: 2+3
First half forming: 1+4
Punch
Steel pipe diameter
Change in highest position of steel plate
Steel plate
Die
(b) First half succeeding forming
2300mm
Entry prohibited region of steel plate (width of driving device)
First half forming: 1+4
First half forming: 2+3
First half forming: 3+2
First half forming: 4+1
Steel pipe diameter
1890mm

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/059835

A. CLASSIFICATION OF SUBJECT MATTER
B21D5/01(2006.01)i, *B21C37/08*(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, B21C37/08

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	WO 2009/023973 A1 (SOUTEC SOUDRONIC AG), 26 February 2009 (26.02.2009), description, page 2, line 9 to page 16, line 6; fig. 1 to 15 (Family: none)	1-4
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 63121/1984(Laid-open No. 176816/1985) (Mitsubishi Heavy Industries, Ltd.), 22 November 1985 (22.11.1985), specification, page 2, line 12 to page 3, line 6; fig. 1 (Family: none)	1-4

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 May 2015 (18.05.15)	09 June 2015 (09.06.15)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/059835

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 2005-324255 A (Nakajima Steel Pipe Co., Ltd.), 24 November 2005 (24.11.2005), specification, paragraphs [0015] to [0022]; fig. 1 (Family: none)	1-4
A	JP 2007-90406 A (Nakajima Steel Pipe Co., Ltd.), 12 April 2007 (12.04.2007), specification, paragraphs [0019] to [0031]; fig. 1 to 9 (Family: none)	1-4
A	JP 2011-56524 A (Sumitomo Heavy Industries Techno-Fort Co., Ltd.), 24 March 2011 (24.03.2011), specification, paragraphs [0017] to [0048]; fig. 1 to 8 (Family: none)	1-4

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2005324255 A **[0005]**
- JP 2007090406 A **[0005]**
- JP 2011056524 A **[0005]**
- JP H08294727 A **[0019]**
- JP S5176158 A **[0019]**