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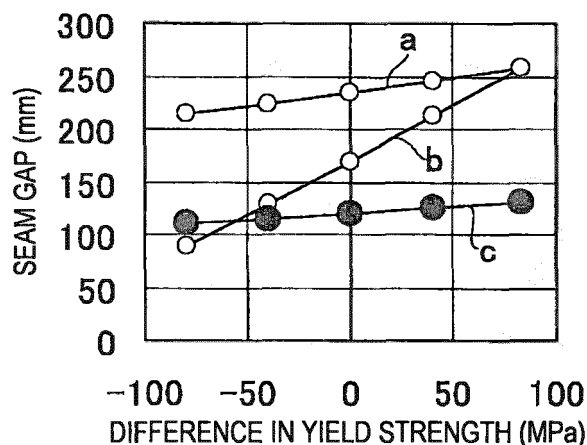
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(54) **METHOD FOR PRESS-MOLDING STEEL PIPE AND METHOD FOR PRODUCING STEEL PIPE**

(57) Provided are a method of press-forming a steel pipe with a small variation in a seam gap at butt welded portion and a method of manufacturing a steel pipe. In a method of press-forming a steel pipe by forming a steel plate by applying press bending to the steel plate a plurality of times, in accordance with a relationship obtained in advance between an additional pressing-down amount which is required further after a state that a predeter-

mined seam gap is formed during applying press bending of a final time to an open seam pipe which is a material to be formed and the predetermined seam gap, forming with the additional pressing-down amount based on the relationship is applied to the open seam pipe from the state that the predetermined seam gap is formed during applying press bending of the final time to the open seam pipe which is the material to be formed.

[FIG. 1]



Description

Technical Field

- 5 **[0001]** The present invention relates to a method of press-forming a steel pipe having a heavy wall thickness and a method of manufacturing a steel pipe by press bending.

Background Art

- 10 **[0002]** As a method of forming a steel pipe having a heavy wall thickness, there has been known a press forming method which uses upper and lower dies shown in Fig. 3 (also referred to as "bending press" hereinafter).

- [0003]** This forming method is for forming a steel plate having a predetermined width and a predetermined length into a steel pipe having a length direction thereof set as a pipe axis direction. In the forming method, bending is applied to width edge portions of the steel plate (hereinafter referred to as "edge crimping") and, subsequently, bending is applied to the steel plate a plurality of times in the width direction of the steel plate, thereby forming the steel plate into a cylinder.

- 15 **[0004]** In a main forming step which follows the edge crimping, as shown in Fig. 3, two dies 1a, 1b are adjusted to have a predetermined distance therebetween, a steel plate S is placed on the dies 1a, 1b, a punch leading end portion 22 which is a leading end portion of a punch 2 of the upper die is pressed down to a position between two dies 1a, 1b, thereby applying bending deformation to the steel plate S. Next, the steel plate S is moved by a predetermined length in the width direction, and the upper die is pressed again. This pressing operation is repeated a plurality of times.

- 20 **[0005]** Usually, the steel plate is sequentially formed toward a center portion of the steel plate in the width direction (C in the drawing) from an edge portion of the steel plate on one side in the width direction (A in the drawing) thus forming the steel plate S from the edge portion of the steel plate on one side to a position immediately in front of the center portion of the steel plate in the width direction (first half of the step). Thereafter, the steel plate S is sequentially formed from an edge portion of the steel plate on the other side opposite to one side in the width direction (B in the drawing), thereby forming the steel plate S from the edge portion of the steel plate on the other side to the center portion of the steel plate in the width direction (C in the drawing) (second half of the step). Lastly, the center portion of the steel plate S in the width direction (C in the drawing) is pressed down (final step). In this manner, an open seam pipe is manufactured. The open seam pipe is a pipe body in a state where the plate material is formed into a cylindrical shape, and open seam edges which face each other in an opposed manner are not welded to each other. In Fig. 3, a dotted line indicates a position of the steel plate S in a state where the punch 2 is not brought into contact with the steel plate S. In Fig. 3, table rollers not shown in the drawing are arranged on left and right sides of the dies 1a, 1b. The table rollers can support the steel plate S at a point B or a point C as indicated by a dotted line in a left upper view in Fig. 3, for example, and also can convey the steel plate S in the left and right directions in the drawing.

- 35 **[0006]** Fig. 4 is a schematic view of an open seam pipe. As shown in Fig. 4, the open seam pipe 3 is a pipe in a state where a plate material used as a raw material is formed into a cylindrical shape, and open seam edges 31a, 31b which face each other in an opposed manner are not welded to each other. A gap g between the open seam edges which face each other in an opposed manner is a seam gap. The pipe axis direction L of the open seam pipe 3 is same as the longitudinal direction of a punch.

- 40 **[0007]** Thereafter, the open seam pipe is conveyed in a longitudinal direction of the steel pipe (the direction perpendicular to a surface of paper on which Fig. 3 is drawn) so that the open seam pipe is transferred to a next step. To enable such conveyance of the open seam pipe, after the final pass forming which is the bending of the final time is finished, the seam gap g of the open seam pipe 3 is required to have a width larger than a thickness of a punch beam 21 which supports the punch leading end portion 22 of the upper die.

- 45 **[0008]** Then, the open seam pipe 3 is constrained by a pressing-down device such that the seam gap g of the open seam pipe 3 is closed. The open seam edges which are made to butt each other are welded to each other by a welder in such a state thus manufacturing a straight seam welded steel pipe. A cylindrical shape of the welded steel pipe is modified by applying diameter expanding forming or a diameter shrinking forming to the welded steel pipe when necessary.

- 50 **[0009]** Adjustment and setting of such press conditions can be performed using a press die provided with a mechanism for adjusting a gap between dies of a lower die disclosed in patent literature 1.

Citation List

- 55 Patent Literature

[0010] PTL 1: JP-A-11-129031

Summary of Invention

Technical Problem

[0011] In constraining an open seam pipe by a pressing-down device such that a seam gap of the open seam pipe is closed and welding open seam edges which are made to butt each other in such a state by a welder, a constraining force of the pressing-down device has an upper limit. Accordingly, there is a case that it is impossible to make open seam edges butt each other by constraining an open seam pipe having an amount of seam gap equal to or more than a fixed amount determined corresponding to a size of a steel pipe. As a result, there is a possibility that the open seam edges which are made to butt each other cannot be also welded to each other.

[0012] Accordingly, at the time of performing the final press in bending press, there has been a demand for making an amount of seam gap as small as possible.

[0013] An amount of seam gap of an open seam pipe is adjusted by gradually increasing a punch pressing-down amount in the final press. When the punch pressing-down amount in the final press is increased, the amount of seam gap is decreased. To the contrary, when the punch pressing-down amount in the final press is decreased, the amount of seam gap is increased.

[0014] When the punch pressing-down is released, since a spring back occurs, a seam gap of an open seam pipe becomes larger after releasing the punch pressing-down than the seam gap of the open seam pipe during the punch pressing-down. Aiming at the decrease of the spring back after releasing the punch pressing-down, there has been proposed a technique where a punch pressing-down amount is increased in a final press such that the punch pressing-down amount is further increased even after open seam edges are brought into contact with a punch support portion thus applying bending to the open seam pipe.

[0015] Here, when a punch pressing-down amount is excessively large, there exists a possibility that a drawback occurs where open seam edges of an open seam pipe strongly clamp a punch support portion so that it is necessary to cut the pipe over the whole length to remove the pipe.

[0016] To overcome such a drawback, usually, an attention has been paid to prevent a punch pressing-down amount from becoming excessively large. As a result, a seam gap is liable to become large.

[0017] In addition to the above-mentioned drawbacks, a yield strength of a steel plate also influences the seam gap. This is because when bending deformation is applied to the steel plate, a spring back amount after bending deformation is generated differs depending on the yield strength of the steel plate. For example, to take the case where press forming of a final pass is performed under the same press condition and, thereafter, a press load is completely removed as an example, a seam gap becomes small when the yield strength of the steel plate S is low, and the seam gap becomes large when the yield strength of the steel plate S is high.

[0018] As described previously, usually, since an attention has been paid so as to prevent a punch pressing-down amount from becoming excessively large, a seam gap is liable to become large. The influence of a yield strength of a steel plate overlaps with this tendency and hence, a variation in a seam gap is also increased. When the seam gap is excessively large, a constraining force necessary for constraining an open seam pipe by closing the seam gap at the time of welding becomes large so that a pressing-down device becomes large-sized. Further, to cope with the variation in the seam gap, it takes a considerable time when a pressing-down amount of the pressing-down device is manually adjusted in the welder.

[0019] In view of the above, to suppress a variation in a seam gap after pressing, there has been proposed a technique where a press condition is adjusted for each steel plate and a technique where a table which shows the relationship between yield strengths and press conditions of steel plates is prepared in advance and a press condition is determined based on the table.

[0020] In the technique disclosed in PTL 1, a bent shape of the steel plate can be adjusted by adjusting a distance between dies of a lower die. With respect to a variation in a spring back amount, a shape of a steel pipe is measured after the steel pipe is formed from a steel plate in a first step and, thereafter, modification forming is performed in a second step by adjusting the distance between the dies of the lower die. In other words, according to the technique described in PTL 1, the bent shape of the steel pipe is measured in a state where a load is removed after forming in the first step is finished, that is, in a state where a spring back occurs and, thereafter, modification forming in the second step is performed by adjusting a press condition such as a pressing-down amount, a load, a distance between the dies of the lower die or the like in accordance with a result of measurement. Accordingly, in resetting the distance between the dies of the lower die, it is necessary to ensure a time for such resetting. Particularly when modification forming is performed a plurality of times to form one steel pipe, the number of times of shape measurement becomes also a plurality of times and hence, there arises a drawback that productivity is largely lowered. Further, it is necessary to set conditions for performing such modification forming for each steel plate and hence, the large lowering of the productivity is unavoidable in the manufacture of steel pipes from a large number of steel plates having a variation in a spring back amount.

[0021] Accordingly, it is an object of the present invention to provide a method of press-forming a steel pipe with a

small variation in a seam gap.

Solution to Problem

[0022] The gist of the present invention is as follows.

[1] A method of press-forming a steel pipe by forming a steel plate by applying press bending to the steel plate a plurality of times, wherein, in accordance with a relationship obtained in advance between an additional pressing-down amount which is required further after a state that a predetermined seam gap is formed during applying press bending of a final time to an open seam pipe which is a material to be formed and the predetermined seam gap, forming with the additional pressing-down amount based on the relationship is applied to the open seam pipe after the state that the predetermined seam gap is formed during applying press bending of the final time to the open seam pipe which is the material to be formed.

[2] The method of press-forming a steel pipe according to [1], wherein the predetermined seam gap is a seam gap at a point of time that open seam edges of the steel plate are brought into contact with a punch beam of an upper die.

[3] A method of manufacturing a steel pipe, wherein the open seam edges of the open seam pipe formed by the method of press-forming a steel pipe according to [1] or [2] are made to butt each other and are welded to each other.

Advantageous Effects of Invention

[0023] According to the present invention, pressing is performed under a condition set in advance and hence, a press material having a small variation in a seam gap can be acquired whereby it is unnecessary to perform modification forming or to set and adjust a gap between dies of a lower die thus remarkably enhancing productivity.

Brief Description of Drawings

[0024]

[Fig. 1] Fig. 1 shows a view showing the relationship between the difference in yield strength and a seam gap according to the present invention.

[Fig. 2] Fig. 2 shows a view showing the relationship between the difference in yield strength and a seam gap according to the prior art.

[Fig. 3] Fig. 3 shows a schematic view for explaining a forming step in steel pipe manufacturing steps.

[Fig. 4] Fig. 4 shows a schematic view of an open seam pipe.

[Fig. 5] Fig. 5 shows schematic views for explaining an edge crimping step, wherein Fig. 5A shows a set state at the time of edge crimping, Fig. 5B shows a state at the time of finishing applying an edge crimping load, and Fig. 5C shows a state after removing an edge crimping load.

[Fig. 6] Fig. 6 shows schematic views for explaining a press forming step, wherein Fig. 6A shows a load applying state, Fig. 6B shows a state after the load is removed, and Fig. 6C shows a cross-sectional shape of a pipe after press forming.

Description of Embodiments

[0025] API standards are the general standards for line pipes where straight seam welded steel pipes are mainly used. According to the API standards, a range from an upper limit to a lower limit of an yield strength of a welded steel pipe of grade X80 is 138 MPa. A steel plate used as a raw material of a welded steel pipe also has a yield strength which substantially falls in the same range as that of the welded steel pipe. Particularly, in manufacturing a steel pipe having high yield strength, a steel plate which becomes a raw material of the welded steel pipe is manufactured by a TMCP method. Accordingly, an yield strength of the steel plate is also liable to vary because of a variation in chemical components condition, a rolling condition and a cooling condition.

[0026] Hereinafter, the explanation is made with respect to the case where a steel pipe at a grade of API X80 having an outer diameter of 1219 mm and a pipe thickness of 31.8 mm is formed. However, the present invention is not limited to the embodiment described hereinafter.

[0027] In the forming method, firstly, edge crimping is performed as shown in Fig. 5. In Fig. 5, symbol 41 indicates an edge crimping lower die, and symbol 42 indicates an edge crimping upper die. Edge crimping is performed such that a crimp edge angle j (Fig. 5B) becomes 28 degrees at the time of applying a press load within a range h (Fig. 5A) having a width of 240 mm at an edge portion of a steel plate in the width direction. A bent angle k (Fig. 5C) of an edge portion of the steel plate in the width direction after removing the press load is 23 degrees.

[0028] Next, bending is applied to the steel plate sequentially 11 times in the steel plate width direction from edge portions of the steel plate in the width direction by a punch 2 (upper die) where a radius R of the punch leading end portion 22 shown in Fig. 6A is 415 mm. The forming method at this point of time is explained by reference to Fig. 6. In Fig. 6A, the punch 2 (upper die) is constituted of a punch beam 21 and a punch leading end portion 22, and a lower die is constituted of dies 1a, 1b. An entire bent angle of the steel plate excluding a seam gap of edge crimping (f in Fig. 6C) is obtained by combining a total value of bent angles of from eleven times of bending and a bent angle of edge crimping. To be more specific, bending is applied to a steel plate having a yield strength of 640 MPa with a bent angle (d in Fig. 6A) at the time of applying a load per one bending being set to 35 degrees such that a bent angle after removing a load (e in Fig. 6B) becomes 29 degrees. With respect to bending ranges of the steel plate S, a range "a" shown in Fig. 6A indicates a preceding-time bending range, a range "b" shown in Fig. 6A indicates a this-time bending range, and a range "c" shown in Fig. 6A indicates a next-time and succeeding bending ranges. In such bending, the adjustment of a bending amount is performed in general such that a moving amount of the punch 2 is directly controlled by a press device. Here, forming is performed by setting an amount that the punch 2 is lowered from a state where the punch leading end portion 22 is brought into contact with an upper surface position of the steel plate (hereinafter, a lowering amount of the punch 2 from a reference point being referred to as a pressing-down amount and the upper surface position of the steel plate being taken as a reference unless otherwise specified) to a fixed value.

[0029] Fig. 2 shows the relationship between the yield strength difference which is the difference in yield strength of a steel plate with respect to 640 MPa which is a reference value of yield strength of the steel plate and a seam gap in a state where a load is removed after pressing is finished.

[0030] Even when steel plates have the same bent shape at the time of applying a bending load to the steel plates, that is, in a pressing-down state of the steel plates, a spring back amount of the steel plate becomes large, when a raw material of a steel plate has a high yield strength. Accordingly, a bent angle of the steel plate after forming becomes small so that a seam gap after removing a load becomes large. As shown in Fig. 2, when the yield strengths of the raw material steel plates differ from each other by 160 MPa, the difference in seam gap in a state where a load is removed after pressing becomes 170 mm. This amount corresponds to 14% of an outer diameter of the open seam pipe and is an extremely large value.

[0031] Accordingly, Fig. 1 shows the relationship between the yield strength difference and a seam gap in a state where a load is removed after pressing when bending in an intermediate step is performed by a conventional forming method and a pressing-down amount in the final forming pass (eleventh pass) is changed. In Fig. 1, as a reference, a result of the prior art shown in Fig. 2 (graph b) is also described.

[0032] A graph c indicates the present invention example where open seam edges are brought into contact with the punch beam 21 of the upper die and, thereafter, the steel plate is further pressed down by 9 mm to ensure the same deformation amount in the final forming pass (eleventh pass). The difference in seam gap in a state where a load is removed after pressing is small, that is, 20 mm. Accordingly, it is understood that the substantially uniform seam gaps can be obtained regardless of a yield strength of the steel plate.

[0033] A graph a indicates an example where pressing-down is performed until the open seam edges are brought into contact with the punch beam portion of the upper die. To compare with the prior art (graph b, pressing-down amount being fixed), a deviation in the seam gap in a state where a load is removed after pressing is small. However, the seam gap in a state where a load is removed is large compared to the seam gap of the above-mentioned present invention example.

[0034] The reason pressing-down is further performed by 9 mm after the open seam edges are brought into contact with the punch beam 21 of the upper die is based on the following technical concept.

[0035] When a plurality of steel pipes having the same size are manufactured, firstly, a plurality of open seam pipes having the same size are formed. Here, the press condition is basically fixed and hence, a deformation mode from a steel plate which is a raw material to an open seam pipe is basically the same. Accordingly, by setting a pressing-down amount to be further added from such a state as a fixed value with reference to a predetermined shape in the course of a final press, a seam gap in a state where a load is removed after the final press also becomes a fixed value.

[0036] As described previously, when an open seam pipe is formed from a steel plate using two dies 1a, 1b and one punch 2, the use of a seam gap as an index of a predetermined shape in the course of the final press where a pressing-down amount to be further added is set to a fixed value is simple and effective.

[0037] In the above-mentioned example, as the seam gap which is an index of a predetermined shape in the course of the final press where the pressing-down amount to be added is set to a fixed value, the seam gap at a point of time that the open seam edges on both sides are brought into contact with the punch beam 21 of the punch 2 is adopted. Here, a pressing-down amount to be further added from a point of time that both open seam edges on both sides are brought into contact with the punch beam 21 of the upper die 2 is grasped and determined by performing a preparatory forming in advance or by referencing the past manufacturing records.

[0038] With respect to the reference of the seam gap which is an index of a shape by which a pressing-down amount to be further added becomes a fixed value, the explanation has been made with respect to the case where both open

seam edges on both sides are brought into contact with the punch beam 21 of the punch 2, that is, with respect to the case where the seam gap agrees with a thickness of the punch beam 21. However, the present invention is not limited to such a case. For example, the determination that the seam gap reaches a predetermined value, for example, can be performed by using a detector of a type by which a position of a plate end can be measured any time or a simplified detector of a type which determines that a plate end arrives at a certain position.

[0039] To be more specific, for example, a light projector and a light receiver are mounted on the punch beam 21. An amount of received light which the light receiver receives changes when the open seam edge of the open seam pipe blocks an optical path to the light receiver from the light projector. The position of the open seam edge can be detected based on such a change in amount of light by the light receiver. On the other hand, when it is sufficient to detect a point of time that the open seam edges are brought into contact with the punch beam 21 of the upper die 2, it is not always necessary to constantly measure the position of the plate end portion. For example, the determination that the seam gap reaches a predetermined value can be realized by a change in an electrical conduction state which is brought about by a contact between the open seam edges and the punch beam 21 or the confirmation of the presence or the non-presence of the contact by mounting a piezoelectric element on a contact expected portion.

[0040] As a control method of applying forming with a further required pressing-down amount from a state where the open seam pipe has a predetermined seam gap in the course of pressing-down in the final press, for example, a signal may be transmitted to a pressing-down device of a press forming device at a point of time that the seam gap becomes the predetermined seam gap amount, and forming with an additional pressing-down amount which is decided in advance separately may be performed using such a signal as a trigger. An additional pressing-down amount can be measured by measuring a moving amount of the punch 2. In the case where the seam gap when the predetermined seam gap becomes equal to the thickness of the punch beam 21 or the seam gap at the point of time that the open seam edges are brought into contact with the punch beam 21 is used as the reference, an amount that the open seam edges which are brought into contact with the punch beam 21 slide upward along the punch beam 21 may be detected and an additional pressing-down amount may be controlled with reference to this slide-up amount of the open seam edges.

[0041] In manufacturing a steel pipe using an open seam pipe manufactured by the above-mentioned press forming method, open seam gaps of an open seam pipe are continuously tack welded to each other by the continuous tack welder and, thereafter, main welding may be performed in order of inside welding and outside welding. It is preferable to increase circularity of a steel pipe to which main welding is applied by expanding the steel pipe using a pipe expanding device. A pipe expanding step is performed while usually setting a pipe expanding ratio (a ratio of an amount of change in an outer diameter of the pipe after expanding the pipe with respect to the outer diameter of the pipe before expanding the pipe) to a value which falls within a range from 0.3% to 1.5%. From a viewpoint of a balance between a circularity enhancing effect and ability which the pipe expanding device is required to possess, the pipe expanding ratio may preferably be set to a value which falls within a range from 0.5% to 1.2%.

Example 1

[0042] To manufacture a steel pipe having an outer diameter of 1219 mm, a pipe thickness of 31.8 mm and a length of 12 m, 10 pieces of steel plates of AP1 X80 grade having a length of 24 m are prepared. Each steel plate is divided in three in the longitudinal direction thus preparing three sets of specimens where each set is constituted of 10 pieces of specimens. A plate width of these steel plates is set to 3693 mm by machining, and edge crimping is applied to both respective edge portions of each steel plate in the width direction within a range of width of 180 mm using a die having a radius of R380 mm and, thereafter, press forming is performed.

[0043] In performing press forming, a punch whose punch leading end portion 22 has a radius of R415 mm is used as a punch 2 of an upper die. As a lower die, dies 1 having a radius of R100 mm are set in a spaced-apart manner with a gap of 540 mm (the gap being a distance between peak points of two dies 1a, 1b of the lower die). The press forming is performed 11 times in a divided manner. A thickness of the punch beam 21 is 100 mm.

[0044] Set positions in the width direction from the first pass to tenth pass (distance from the center between two dies of the lower die to the center of the steel plate in the width direction) and pressing-down amounts are shown in Table 1. The pressing-down amounts are determined such that the approximately whole circumference of the open seam pipe is bent except for the seam gap portion as a result of edge crimping and press forming performed eleven times in total under a condition that a yield strength of the steel plate is 615 MPa.

[Table 1]

Pass	1	2	3	4	5	6	7	8	9	10
Position in widthwise direction of steel plate (mm)	1515	1212	909	606	303	-1515	-1212	-909	-606	-303

(continued)

Pass	1	2	3	4	5	6	7	8	9	10
Pressing-down amount (mm)	78.0	75.2	73.5	73.5	73.5	78.0	75.2	73.5	73.5	73.5

[0045] As the order of forming in the forming step of the method according to the example, as shown in Fig. 3 which is a press step view, a first half step is constituted of passes 1 to 5, and a second half step is constituted of passes 6 to 10. In the passes 1 to 5 which constitute the first half step, the steel plate is sequentially formed from an edge portion on one side of the steel plate in the width direction to a center portion of the steel plate in the width direction. The forming is performed from the edge portion on one side of the steel plate to the position in front of the center portion of the steel plate in the width direction by an amount corresponding to a press of one time. Next, in the passes 6 to 10 which constitute the second half step, the steel plate is sequentially formed from an edge portion on the other side of the steel plate in the width direction from the edge portion on the other side of the steel plate to the center portion of the steel plate in the width direction. Lastly (in the eleventh pass), a pressing force is applied to the center portion of the steel plate in the width direction.

[0046] Using ten pieces of steel plates (steel plates No. A to J) having different yield strengths, pressing is performed ten passes for each steel plate at steel plate widthwise positions indicated in Table 1 (in Table, the steel plate widthwise position being expressed by distance with "+" in the direction toward A from the width center C of the steel plate and being expressed by distance with "-" in the direction toward B from the width center C of the steel plate). Thereafter, the eleventh path is performed, and the seam gap in a state where a load is removed after pressing is measured. The result of measurement (the relationship between the yield strength of the steel plate and the seam gap after pressing) is shown in Table 2.

[Table 2]

Steel plate No.	A	B	C	D	E	F	G	H	I	J	Variation in seam gap (mm)	Required time (min)	Evaluation	Remarks
Yield strength (MPa)	679	657	638	615	611	609	605	598	581	560	-	-	-	-
	139	142	123	118	126	120	125	114	119	107	35	59	Good	Present invention example
Seam gap (mm)	219	232	157	141	170	149	166	126	140	-	92	56	Bad	Comparison example 1
	125	112	123	130	131	108	107	139	119	122	31	83	Fair	Comparison example 2

[0047] In the final pass (eleventh pass), a steel plate is set such that the center of the steel plate in the width direction is disposed at the center of the lower die. In the present invention example, to allow the steel plate having a yield strength of 615 MPa to have a seam gap of 125 mm after pressing, edge portions of the steel plate in the width direction, that is, open seam edges of an open seam pipe are brought into contact with the punch beam 21 and, thereafter, the steel plate is further pressed down by 9 mm. In the comparison example 1, to allow a steel plate having the lowest yield strength of 560 MPa to have a seam gap of 100 mm in a state where a load is removed after pressing, a pressing-down amount which is an amount that the punch 2 is lowered from an upper surface position of the steel plate is set to 48.6 mm. In the comparison example 2, firstly, a steel plate is pressed down until open seam edges of an open seam pipe are brought into contact with the punch beam 21, and a seam gap is confirmed in a state where a load is removed after pressing, a distance between the dies 1a, 1b of the lower die is adjusted and, thereafter, the pressing-down is repeated.

[0048] According to the present invention examples, a variation (= a maximum value - a minimum value) in the seam gap after 10 pieces of steel pipes are pressed is small, a required time for press forming is also short so that both a favorable steel pipe shape and a high operation efficiency can be acquired.

[0049] To the contrary, although a required time for press forming is slightly short in the comparison example 1, in the steel plate J having the lowest yield strength, a state is brought about where the open seam edges clamp the punch beam 21. Accordingly, it is necessary to stop a line for taking out a formed member (open seam pipe) and hence, it is difficult to adopt the comparison example 1 for industrial production thereof. Further, in the comparison example 2, a required time is 1.4 times as long as that of the present invention example thus lowering the productivity, although the open seam pipe has a stable shape.

Industrial Applicability

[0050] The method for press-forming a steel pipe and a method of manufacturing a steel pipe according to the present invention are not limited to the manufacture of a steel pipe having a large diameter and a heavy wall thickness, and are applicable to all methods of manufacturing a steel pipe by performing the three point bending press.

Reference Sign List

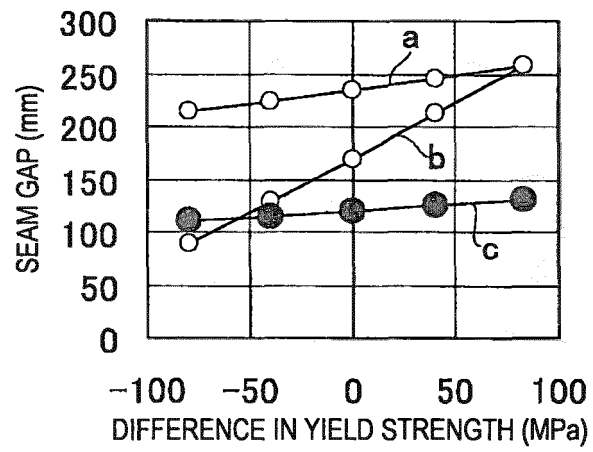
[0051]

- 1a, 1b: dies
- 2: punch
- 21: punch beam
- 22: punch leading end portion
- 3: open seam pipe
- 31a, 31b: plate end portion
- 41: lower die for edge crimping
- 42: upper die for edge crimping

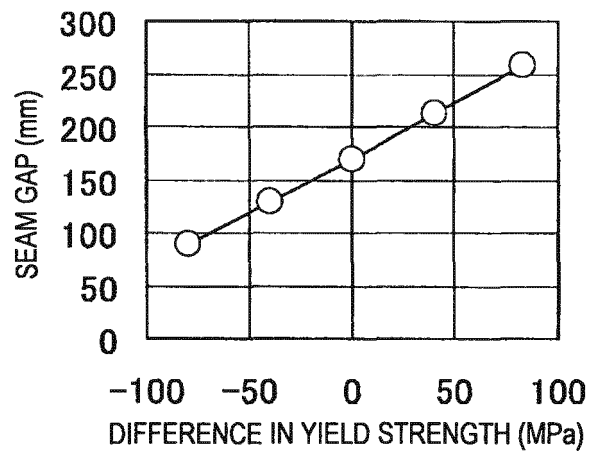
Claims

1. A method of press-forming a steel pipe by forming a steel plate by applying press bending to the steel plate a plurality of times, wherein, in accordance with a relationship obtained in advance between an additional pressing-down amount which is required further after a state that a predetermined seam gap is formed during applying press bending of a final time to an open seam pipe which is a material to be formed and the predetermined seam gap, forming with the additional pressing-down amount based on the relationship is applied to the open seam pipe after the state that the predetermined seam gap is formed during applying press bending of the final time to the open seam pipe which is the material to be formed.
2. The method of press-forming a steel pipe according to claim 1, wherein the predetermined seam gap is a seam gap at a point of time that open seam edges of the steel plate are brought into contact with a punch beam of an upper die.
3. A method of manufacturing a steel pipe, wherein the open seam edges of the open seam pipe formed by the method of press-forming a steel pipe according to claim 1 or 2 are made to butt each other and are welded to each other.

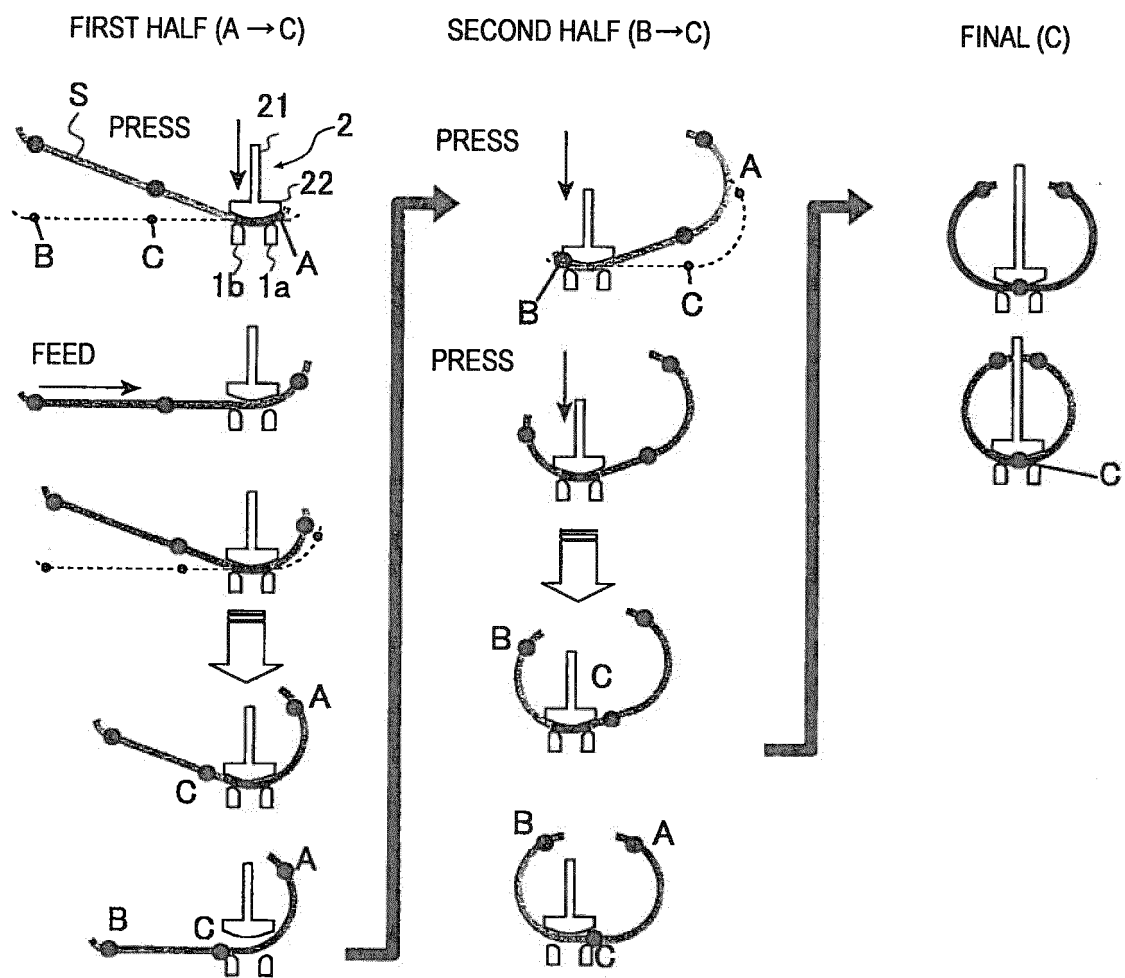
[FIG. 1]



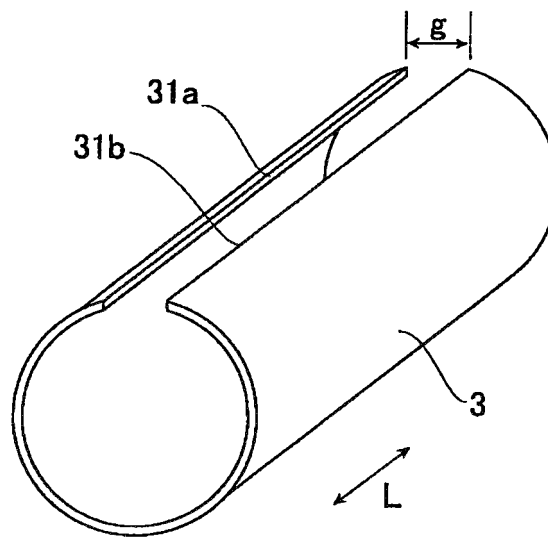
[FIG. 2]



[FIG. 3]



[FIG. 4]



[FIG. 5]

FIG. 5A

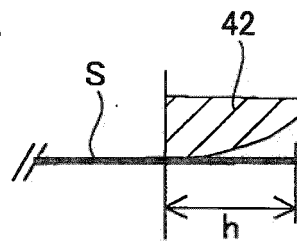


FIG. 5B

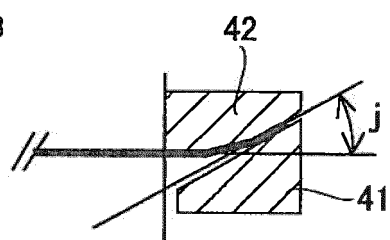
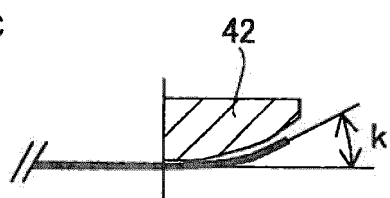


FIG. 5C



[FIG. 6]

FIG. 6A

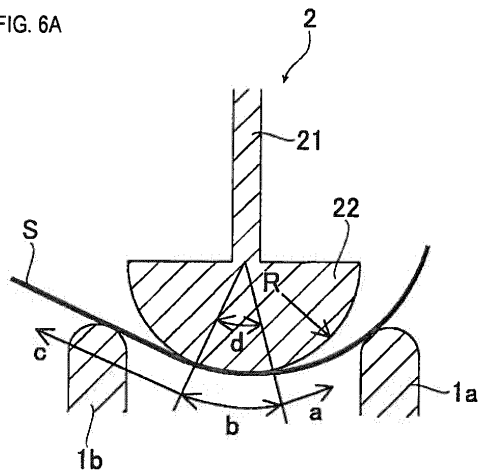


FIG. 6B

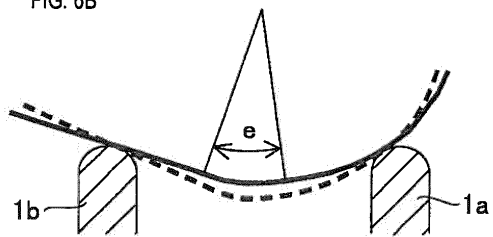
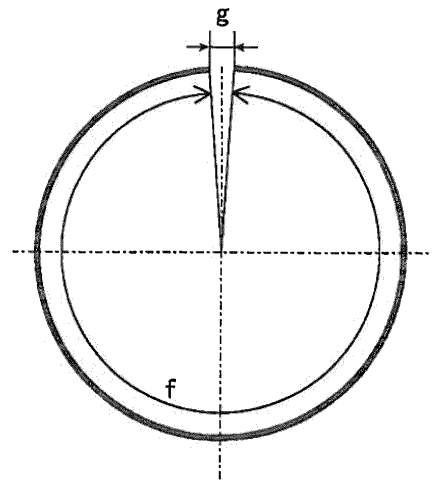


FIG. 6C



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/003435

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 1996-2013
 Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

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 2012-170977 A (JFE Steel Corp.), 10 September 2012 (10.09.2012), paragraphs [0006], [0012] to [0013]; fig. 3 to 4 (Family: none)	1-3
Y	JP 10-166059 A (Mitsubishi Heavy Industries, Ltd.), 23 June 1998 (23.06.1998), paragraphs [0007], [0013]; fig. 4 (Family: none)	1-3
A	JP 2003-154411 A (Chuo Spring Co., Ltd.), 27 May 2003 (27.05.2003), paragraphs [0009], [0020] (Family: none)	1-3

☐ 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
20 August, 2013 (20.08.13)Date of mailing of the international search report
03 September, 2013 (03.09.13)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

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

REFERENCES CITED IN THE DESCRIPTION

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