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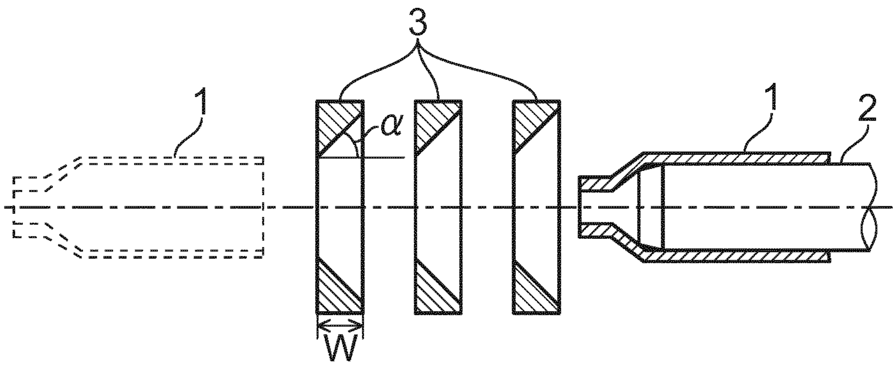
(54) **METHOD FOR MANUFACTURING SEAMLESS PIPE**

(57) A method of manufacturing a seamless steel pipe including the steps of: providing a hollow billet with a mandrel inserted therein and forging the hollow billet into a primary hollow shell of a predetermined diameter and thickness; subjecting the primary hollow shell to diameter reduction at one end portion thereof; and providing the primary hollow shell with a mandrel inserted therein, the primary hollow shell having the diameter reduced portion at the one end portion thereof, and subjecting the primary hollow shell to push-drawing using a push bench. With this method, it is possible to manufacture seamless steel pipes of a wide range of manufacturable sizes (large diameter or thick-walled pipes) with high dimensional accuracy, particularly with high wall thickness accuracy.

FIG.3



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Description

TECHNICAL FIELD

[0001] The present invention relates to a method of manufacturing a seamless steel pipe which is capable of manufacturing seamless steel pipes of a wide range of sizes with high dimensional accuracy. Specifically, the present invention relates to a method of manufacturing a seamless steel pipe which includes preparing a primary hollow shell by a mandrel forging pipe-making process, and applying a push bench pipe-making process to the prepared primary hollow shell.

[0002] Unless otherwise specified, the definitions of certain terms as used in this specification are as follows.

[0003] "Hollow billet": a billet to be subjected to Step 1 as described in this specification (mandrel forging pipe-making step). This is a billet prepared by hot piercing an ingot and forming it into a hollow shape;

[0004] "Primary hollow shell": a shell to be subjected to Step 2 as described in this specification (diameter reduction step). This is a shell that is formed from a hollow billet in Step 1;

[0005] "Hollow shell": a shell to be subjected to a push bench thickness reduction process as described in this specification. This is a shell that was subjected to sizing of the inner and outer surfaces in a push bench sizing process;

[0006] "Large diameter": a pipe outside diameter of 1000 mm or greater; and

[0007] "Dimensional accuracy": absolute values of size deviations in outside diameter and wall thickness of a finished pipe from desired sizes.

BACKGROUND ART

[0008] For application in large diameter pipes such as, for example, large diameter reheat steam pipes for use in a thermal power plant, spiral steel pipes are typically employed. In recent years, large diameter pipes have been required to meet the increasing demand for higher performance such as the increase in the vapor pressure setting for large diameter reheat steam pipes for use in a thermal power plant. Accordingly, there is an increasing need for large diameter seamless steel pipes of high quality.

[0009] In the past, there were examples in which a mandrel forging pipe-making process was employed as a method for hot forming of large diameter seamless steel pipes.

[0010] A mandrel forging pipe-making process is a process that includes: providing a hollow billet with a mandrel inserted therein; and hot working the hollow billet by open-die forging to gradually reduce the wall thickness thereof, as disclosed in Patent Literature 1.

[0011] One advantage of a mandrel forging pipe-making process lies in the wide range of pipe sizes that can be achieved by performing repeated forging and reheating. That is, manufacture of thick-walled, large diameter seamless steel pipes is possible.

[0012] On the other hand, a disadvantage of a mandrel forging pipe-making process is poor dimensional accuracy which results from the forming by forging. Because of this, in the finish machining process after the hot pipe making process, the amount of removal by machining on the steel pipe surface is large, and therefore the yield is low.

CITATION LIST

PATENT LITERATURE

[0013]

PATENT LITERATURE 1: Japanese Patent Publication No. H07-22802

PATENT LITERATURE 2: Japanese Patent Application Publication No. S56-128611

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0014] An object of the present invention is to provide a method of manufacturing a seamless steel pipe which is capable of achieving high dimensional accuracy, particularly high wall thickness accuracy, as well as a wide range of manufacturable sizes (large diameter or thick-walled pipes).

SOLUTION TO PROBLEM

[0015] The present inventor turned his attention to push bench pipe-making processes, which are capable of manufacturing seamless steel pipes with high wall thickness accuracy. As disclosed in Patent Literature 2, a push bench pipe-making process is a process that includes: providing a hollow steel workpiece with a mandrel inserted therein, the hollow steel workpiece having a closed end; and push-drawing the workpiece through a die assembly to reduce the wall thickness thereof. One advantage of push bench pipe-making processes is the high dimensional accuracy which is achieved by the use of inside and outside sizing tools such as a mandrel and a die assembly. Because of this, in the finish machining process, the amount of removal by machining on the pipe surface is small, and therefore the yield is high.

[0016] Taking advantage of both the mandrel forging pipe-making process and the push bench pipe-making process may enable manufacture of seamless steel pipes of a wide range of sizes with high dimensional accuracy. However, in push bench pipe-making processes, it is necessary to use hollow steel workpieces that have a closed end. That is, seamless steel pipes prepared by a mandrel forging pipe-making process cannot be used in a push bench pipe-making process in the as-prepared state as a workpiece to be processed. This is because since they do not have a closed end, they cannot be pushed by a mandrel to pass through a die assembly.

[0017] In view of the above, the present inventor contemplated methods that will allow seamless steel pipes prepared by a mandrel forging pipe-making process to be subjected to a push bench pipe-making process. After an undue amount of trial and error, the present inventor has found that the two pipe-making methods can be utilized in combination by: subjecting a seamless steel pipe prepared by a mandrel forging pipe-making process to diameter reduction at one end portion thereof so that the outside and inside diameters of the end portion are reduced and the diameter reduced end portion can serve as a substitute for a closed end.

[0018] The present invention has been accomplished based on the results of the contemplation and is summarized as a method of manufacturing a seamless steel pipe which includes the steps of:

(1) providing a hollow billet with a mandrel inserted therein and forging the hollow billet into a primary hollow shell of a predetermined diameter and thickness;
(2) subjecting the primary hollow shell to diameter reduction at one end portion thereof to reduce outside and inside diameters of the end portion; and
(3) providing the primary hollow shell with a mandrel inserted therein, the primary hollow shell having the diameter reduced portion at the one end portion thereof, and subjecting the primary hollow shell to push-drawing using a push bench.

ADVANTAGEOUS EFFECTS OF INVENTION

[0019] The method of manufacturing a seamless steel pipe of the present invention is advantageous in that: it is capable of manufacturing seamless steel pipes of a wide range of sizes (large diameter or thick-walled pipes) with high dimensional accuracy, particularly with high wall thickness accuracy due to the push bench pipe-making process that is applied after the application of the mandrel forging pipe-making process.

BRIEF DESCRIPTION OF DRAWINGS

[0020]

[FIG. 1] FIG. 1 is a longitudinal sectional view of a primary hollow shell after being subjected to diameter reduction at one end portion thereof.
[FIG. 2] FIG. 2 is a side view of a front end portion of a mandrel to be used in the push bench pipe-making step.
[FIG. 3] FIG. 3 is a diagram showing a configuration including a primary hollow shell, a mandrel, and a die assembly in the push bench pipe-making step.
[FIG. 4] FIG. 4 is a diagram illustrating a comparison of the manufacturable sizes of seamless steel pipes between a conventional push bench pipe-making process and the manufacturing method of the present invention.

DESCRIPTION OF EMBODIMENTS

[0021] The manufacturing method includes: Step 1 (mandrel forging pipe-making step); Step 2 (diameter reduction step); and Step 3 (push bench pipe-making step). Each of the steps is described below.

[Step 1 (mandrel forging pipe-making step)]

[0022] In Step 1, primary hollow shells are formed by the following procedure:

(1) Pressing a tool having a sharpened end against a top surface of an ingot disposed with the longitudinal direction thereof oriented vertically while the tool is being rotated, and piercing the ingot into a hollow billet by hot working;
(2) Arranging the hollow billet with the longitudinal direction thereof oriented horizontally and pressing a mandrel against the inner surface of the hollow billet to reduce the wall thickness thereof by hot working while the hollow billet is being rotated.
(3) Repeating the above step (2) one or several times to form a primary hollow shell having a predetermined outside diameter and wall thickness.

[0023] In the mandrel forging pipe-making step, hot forging of the hollow billet is preferably performed within a temperature range of 900°C to 1250°C.

[Step 2 (diameter reduction step)]

[0024] FIG. 1 is a longitudinal sectional view of a primary hollow shell after being subjected to diameter reduction. In Step 2, diameter reduction is performed on one end portion of the primary hollow shell 1 formed in Step 1, while it is being rotated, to reduce the inside and outside diameters thereof.

[0025] The diameter reduced portion is composed of a front end portion 1a located at the front edge of the primary hollow shell 1 and a narrowing diameter portion 1b. The narrowing diameter portion 1b is located between the front end portion 1a and the body portion on which diameter reduction is not performed. The front end portion 1a has a constant outside diameter and wall thickness. The narrowing diameter portion 1b has inside and outside diameters that are reduced toward the front edge.

[0026] If the portion subjected to the diameter reduction step is deformed in Step 3, the diameter reduction step may be performed again as needed. As the method for diameter reduction, not only stamping but also a method of hitting one end portion of the primary hollow shell 1 with a hammer as well as a method of rotary forging with a swager or the like may be employed.

[Shape of the Portion Subjected to Diameter Reduction]

[0027] FIG. 2 is a side view of a front edge portion of a mandrel to be used in the push bench pipe-making step. The mandrel 2 includes: a body portion 2a having a cylindrical shape and a narrowing diameter portion 2b having a truncated cone shape disposed at the front edge of the body portion 2a. The narrowing diameter portion 2b has a diameter that is reduced toward the front edge of the mandrel 2. Typically, the narrowing diameter portion 2b is formed in a tapered shape.

[0028] It is preferred that the diameter reduced portion of the primary hollow shell 1 as processed in Step 2 satisfy the following formula (1) where B (mm) represents an inside diameter at the edge of the diameter reduced portion of the primary hollow shell and D (mm) represents a diameter at the front edge of the mandrel that is used in the push bench pipe-making step. The aim of this is to reduce the possibility that the mandrel 2 breaks through the front end portion 1a and the narrowing diameter portion 1b of the primary hollow shell 1 during the push-drawing process in Step 3 (push bench pipe-making step). Cases that satisfy the formula (1) include a case in which the diameter reduced portion forms a closed end.

$$B < D/4 \ldots (1).$$

[Step 3 (push bench pipe-making step)]

[0029] FIG. 3 is a diagram showing a configuration of a primary hollow shell, a mandrel, and a die assembly in the push bench pipe-making step. The die assembly 3 may be provided as a set of a plurality of dies or a single die. In the die assembly 3, a tapered die is typically employed with a die semi-angle α of 10 to 20° and a die width W of 150 to 200 mm.

[0030] In Step 3, the primary hollow shell 1 having the diameter reduced portion at one end portion thereof is provided with a mandrel 2 inserted therein and subjected to push-drawing using a push bench. Step 3 is preferably divided into two steps, a sizing step and a wall thickness reduction step (hereinafter also referred to as "push bench sizing step" and "push bench wall thickness reduction step," respectively).

[Sizing Step]

[0031] In the sizing step, the primary hollow shell 1 having the diameter reduced portion at one end portion thereof is provided with a mandrel 2 inserted therein and is pushed through the die assembly 3 by hot working to size the inner and outer surfaces. The primary hollow shell 1 is subjected to push-drawing through a tapered die as described above with soft reduction to size the inner and outer surfaces, thereby providing a hollow shell 1 to be processed in the wall thickness reduction step.

[0032] The sizing step is intended to reduce longitudinal variations in the outside diameter and the wall thickness of the primary hollow shell 1 using the die assembly 3. If, for example, there are large irregularities on the outer surface of the primary hollow shell 1, the irregularities may interfere with the tapered die when the primary hollow shell 1 is pushed through the tapered die, thereby making the push-drawing operation difficult or impossible.

[0033] The reduction rate in the sizing step is preferably about 3 to 7%.

[0034] In the sizing step, the portion of the primary hollow shell 1 to be subjected to push-drawing (the portion that was not subjected to diameter reduction) is preferably heated to a temperature ranging from 900°C to 1250°C. The aim of this is to reduce the deformation resistance and facilitate the processing.

[0035] Since the diameter reduced portion is a portion against which the mandrel 2 is pressed, it is preferably cooled by water injection to minimize deformation that may occur during the push-drawing process. In order to make sure that the push-drawing of the primary hollow shell 1 by the mandrel 2 is performed without failure, it is preferred that the diameter reduced portion be kept to a temperature of 500 °C or less. Its lower limit temperature is preferably 400°C. This is because, when cooled to a low temperature, certain types of steel such as, for example, a 9% Cr steel may suffer thermal stress cracking during the martensitic transformation.

[Wall Thickness Reduction Step]

[0036] The hollow shell 1, obtained by the push-drawing process with soft reduction in the sizing step, is processed in the wall thickness reduction step. The wall thickness reduction step also uses a mandrel 2 and a die assembly 3 that have the same configuration as shown in FIG. 2. In selecting the die assembly 3 to be used, it is required that it have the ability to impart a predetermined reduction to the hollow shell 1.

[0037] The wall thickness reduction step includes the following operations:

(1) The hollow shell which has undergone sizing of inner and outer surfaces in the sizing step is pushed through the die assembly 3 having a smaller inside diameter by hot working, whereby it is given a predetermined reduction while the wall thickness thereof is reduced.

(2) By repeating the above step (1) one or several times, it is possible to manufacture seamless steel pipes with high wall thickness accuracy. Specifically, it is possible to limit the deviation from the desired wall thickness to 10 mm or less regardless of the thickness of the wall that has been subjected to the push-drawing process.

[0038] In the wall thickness reduction step too, the body portion to be subjected to push-drawing is preferably heated to a temperature of 900°C to 1250°C to reduce the deformation resistance and facilitate the processing. On the other hand, the temperature of the diameter reduced portion is preferably controlled to 500°C or less by performing water injection or the like in order to make sure that the push-drawing of the hollow shell 1 by the mandrel 2 is performed without failure. Its lower limit temperature is preferably 400°C.

[0039] After Steps 1 to 3 as described above, a finishing process may be incorporated. The finishing step may include the following operations:

(1) Cutting the diameter reduced portion of the seamless steel pipe manufactured in Step 3;
(2) Heat treating the seamless steel pipe as needed after the diameter reduced portion was cut; and
(3) Subjecting the resultant seamless steel pipe to a finishing process by machining or polishing the inner and outer surfaces of the steel pipe to finish it to predetermined surface properties and size.

[Suitable Steel Type]

[0040] Examples of steel types suitable for the above described manufacturing method include the following three types of steel:

(1) Carbon steel having a chemical composition of, by mass %, C: 0.3% or less, Si: 1% or less, Mn: 0.1 to 2%, and N: 0.02% or less, with the balance being Fe and impurities;
(2) Low alloy steel having a chemical composition of, by mass %, C: 0.15% or less, Si: 1% or less, Mn: 0.1 to 2%, Cr: 0.5 to 3.0%, Ni: 0.5% or less, Mo: 0.1 to 3.0%, W: 0 to 2%, Cu: 0.1% or less, and N: 0.002 to 0.030%, with the balance being Fe and impurities; and
(3) High Cr ferritic heat resistant steel having a chemical composition of, by mass %, C: 0.15% or less, Si: 1% or less, Mn: 0.1 to 2%, Cr: 8.0 to 12.5%, Ni: 1.0% or less, Mo: 0.1 to 3.0%, W: 0 to 4%, Cu: 0 to 1.5%, and N: 0.01 to 0.10%, with the balance being Fe and impurities.

EXAMPLES

[0041] Set forth below are examples illustrating how it is possible to manufacture seamless steel pipes with high wall thickness accuracy and to extend the manufacturable size of seamless steel pipes.

(Example 1)

[0042] Example 1 illustrates a case in which the extension of the manufacturable size of the outside diameter was achieved.

1. Pipe Making Schedule in Each Step

(Mandrel Forging Pipe-Making Step)

[0043] A hollow billet (weight: 13850 kg) produced from high Cr ferritic heat resistant steel as described above was provided with a mandrel inserted therein, and formed into a primary hollow shell of 1250 mm in outside diameter, 1090 mm in inside diameter, 80 mm in wall thickness, and 6000 mm in length by the mandrel forging pipe-making process.

(Diameter Reduction Step)

[0044] The resultant primary hollow shell was subjected to diameter reduction at one end portion thereof where the inside and outside diameters were reduced. The resulting inside diameter B at the edge of the diameter reduced portion of the primary hollow shell was 200 mm.

(Push Bench Sizing Step)

[0045] The primary hollow shell having the diameter reduced portion at one end portion thereof was provided with a mandrel having an outside diameter of 1060 mm inserted therein. Then it was subjected to soft reduction in a push bench using a die having an inside diameter of 1240 mm, and was formed into a hollow shell with the inner and outer surfaces thereof sized. The diameter D at the front edge of the mandrel was 950 mm and therefore the formula (1) as previously noted was satisfied.

(Push Bench Wall Thickness Reduction Step)

[0046] The resultant hollow shell was subjected to push-drawing in the push bench using a mandrel having an outside diameter of 1060 mm and dies having inside diameters of 1210 mm and 1190 mm, and was formed into a seamless steel pipe.

(Finishing Step)

[0047] The size of the manufactured seamless steel pipe was 1190 mm in outside diameter, 1060 mm in inside diameter, 65 mm in wall thickness, and 7600 mm in length. A 300 mm length of the seamless steel pipe was cut at the diameter reduced end portion, followed by heat treatment and subsequent machining of the inner and outer surfaces.

2. Comparison of Wall Thickness Accuracy

[0048] The seamless steel pipe manufactured in Example 1 had a size of 1190 mm in outside diameter, 1060 mm in inside diameter, and 65 mm in wall thickness and thus was a large diameter pipe. Nevertheless, it achieved a wall thickness accuracy of less than 10 mm. Subsequently, it was subjected to machining of the inner and outer surfaces, and finished into a size of 1170 mm in outside diameter, 1080 mm in inside diameter, and 45 mm in wall thickness.

[0049] That is, in Example 1, the amount of machining necessary for the finishing process was not more than 10 mm for both inner and outer surfaces.

[0050] For comparison with Example 1, a primary hollow shell, as manufactured from the mandrel forging pipe-making process, having an outside diameter of 1250 mm, an inside diameter of 1090 mm, and a wall thickness of 80 mm, exhibited a wall thickness accuracy of more than 20 mm.

[0051] Based on the above, in Example 1, the amount of machining required is 10 mm at a maximum for both inner and outer surfaces, whereas in Comparative Example, it is assumed that the amount of finish machining required exceeds 25 mm for both inner and outer surfaces. It is therefore seen that Example 1 produces an advantageous effect.

(Example 2)

[0052] Example 2 illustrates a case in which the extension of the manufacturable size of the wall thickness was achieved.

1. Pipe Making Schedule in Each Step

(Mandrel Forging Pipe-Making Step)

[0053] A hollow billet (weight: 25600 kg) produced from high Cr ferritic heat resistant steel as described above was provided with a mandrel inserted therein, and formed into a primary hollow shell of 1050 mm in outside diameter, 640 mm in inside diameter, 205 mm in wall thickness, and 6000 mm in length by the mandrel forging pipe-making process.

(Diameter Reduction Step)

[0054] The resultant primary hollow shell was subjected to diameter reduction at one end portion thereof where the inside and outside diameters were reduced. The resulting inside diameter B at the edge of the diameter reduced portion of the primary hollow shell was 100 mm.

(Push Bench Sizing Step)

[0055] The primary hollow shell having the diameter reduced portion at one end portion thereof was provided with a mandrel having an outside diameter of 610 mm inserted therein. Then it was subjected to soft reduction in a push bench using a die having an inside diameter of 1040 mm, and was formed into a hollow shell with the inner and outer surfaces thereof sized. The diameter D at the front edge of the mandrel was 500 mm and therefore the formula (1) as previously noted was satisfied.

(Push Bench Wall Thickness Reduction Step)

[0056] The resultant hollow shell was subjected to push-drawing in the push bench using a mandrel having an outside diameter of 610 mm and dies having inside diameters of 1010 mm and 990 mm, and was formed into a seamless steel pipe.

(Finishing Step)

[0057] The size of the manufactured seamless steel pipe was 990 mm in outside diameter, 610 mm in inside diameter, 190 mm in wall thickness, and 6800 mm in length. A 300 mm length of the seamless steel pipe was cut at the diameter reduced end portion, followed by heat treatment and subsequent machining of the inner and outer surfaces.

2. Comparison of Wall Thickness Accuracy

[0058] The seamless steel pipe manufactured in Example 2 had a size of 990 mm in outside diameter, 610 mm in inside diameter, and 190 mm in wall thickness and thus was a thick walled pipe. Nevertheless, it achieved a wall thickness accuracy of less than 10 mm. Subsequently, it was subjected to machining of the inner and outer surfaces, and finished into a size of 970 mm in outside diameter, 630 mm in inside diameter, and 170 mm in wall thickness.

[0059] That is, in Example 2 too, the amount of machining necessary for the finishing process was not more than 10 mm for both inner and outer surfaces.

[0060] For comparison with Example 2, a primary hollow shell, as manufactured from the mandrel forging pipe-making process, having an outside diameter of 1050 mm, an inside diameter of 640 mm, and a wall thickness of 205 mm, was examined to find the wall thickness accuracy thereof. As with Example 1, it was found that its wall thickness accuracy was more than 20 mm.

[0061] Based on the above, in Example 2, the amount of machining required is 10 mm at a maximum for both inner and outer surfaces, whereas in Comparative Example, it is assumed that the amount of finish machining required exceeds 25 mm for both inner and outer surfaces. It is therefore seen that Example 2 produces an advantageous effect.

[0062] FIG. 4 is a diagram illustrating a comparison of the manufacturable size of seamless steel pipes between a conventional push bench pipe-making process and Example 1 or Example 2. The manufacturable size is defined herein as a size that meets the requirement of the wall thickness accuracy of 10 mm or less.

[0063] As can be seen from FIG. 4, when the push bench pipe-making process was employed alone (comparative example), the largest size that was achieved in manufacturing the seamless steel pipe while meeting the wall thickness accuracy of 10 mm or less was as follows: the largest outside diameter of 850 mm or the largest wall thickness of 150 mm. In contrast, in Example 1 or 2, the manufacturable size of seamless steel pipes was extended to the largest outside diameter of 1200 mm or the largest wall thickness of 170 mm.

INDUSTRIAL APPLICABILITY

[0064] With the method of manufacturing a seamless steel pipe according to the present invention, it is possible to manufacture seamless steel pipes of a wide range of sizes (large diameter or thick-walled pipes) with high dimensional accuracy, particularly with high wall thickness accuracy.

REFERENCE SIGNS LIST

[0065]

1: primary hollow shell, hollow shell, 1a: front end portion,
1b: narrowing diameter portion, 2: mandrel, 2a: body portion,
2b: narrowing diameter portion, 3: die assembly

Claims

1. A method of manufacturing a seamless steel pipe, **characterized in that** the method comprises the steps of:

providing a hollow billet with a mandrel inserted therein and forging the hollow billet into a primary hollow shell of a predetermined diameter and thickness;
subjecting the primary hollow shell to diameter reduction at one end portion thereof to reduce outside and inside diameters of the end portion; and
providing the primary hollow shell with a mandrel inserted therein, the primary hollow shell having the diameter reduced portion at the one end portion thereof, and subjecting the primary hollow shell to push-drawing using a push bench.

FIG.1

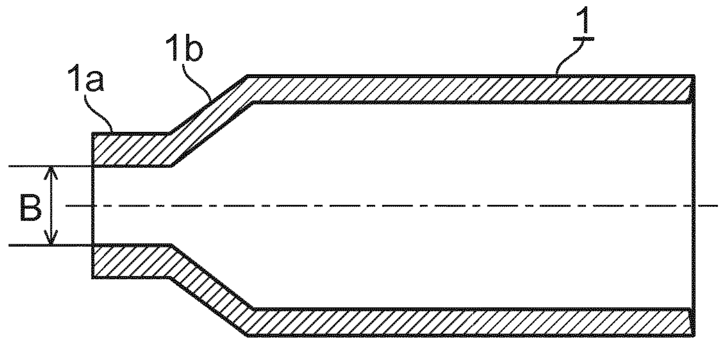


FIG.2

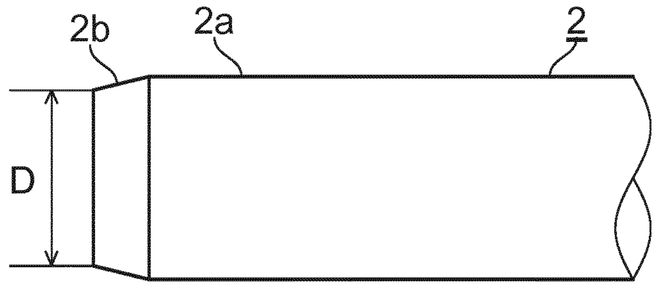


FIG.3

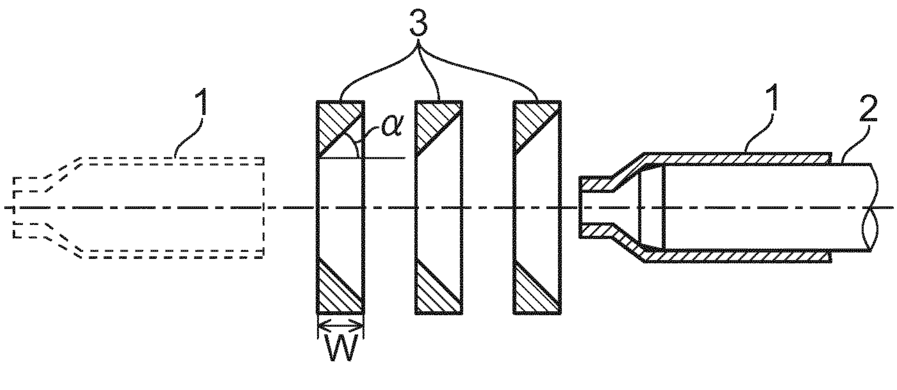
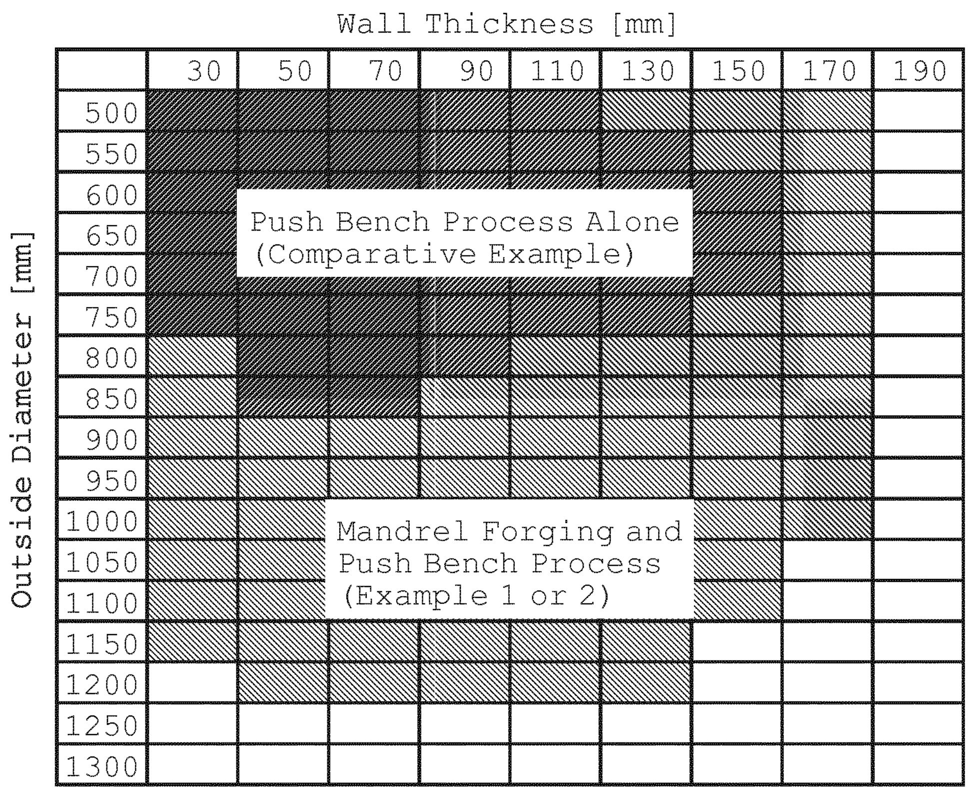


FIG.4


Wall Thickness [mm]
30
50
70
90
110
130
150
170
190
Outside Diameter [mm]
500
550
600
650
700
750
800
850
900
950
1000
1050
1100
1150
1200
1250
1300
Push Bench Process Alone
(Comparative Example)
Mandrel Forging and
Push Bench Process
(Example 1 or 2)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/000596

A. CLASSIFICATION OF SUBJECT MATTER
B21C1/26(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)
B21C1/26

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 60-240332 A (NKK Corp.), 29 November 1985 (29.11.1985), claims (Family: none)	1
Y	JP 61-1413 A (NKK Corp.), 07 January 1986 (07.01.1986), page 2, upper right column, line 11 to lower right column, line 14 (Family: none)	1
Y	JP 63-154211 A (Sumitomo Metal Industries, Ltd.), 27 June 1988 (27.06.1988), page 2, lower right column, line 11 to page 3, upper left column, line 4; fig. 1 (Family: none)	1

☒ 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
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 April, 2013 (11.04.13)	23 April, 2013 (23.04.13)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/000596

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 57-56117 A (Miyata Industry Co., Ltd.), 03 April 1982 (03.04.1982), claim 1; fig. 1 to 6 (Family: none)	1

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H0722802 B **[0013]**
- JP S56128611 B **[0013]**