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(71) Applicant: **Sumitomo Metal Industries Limited**
Osaka-shi, Osaka 541-0041 (JP)

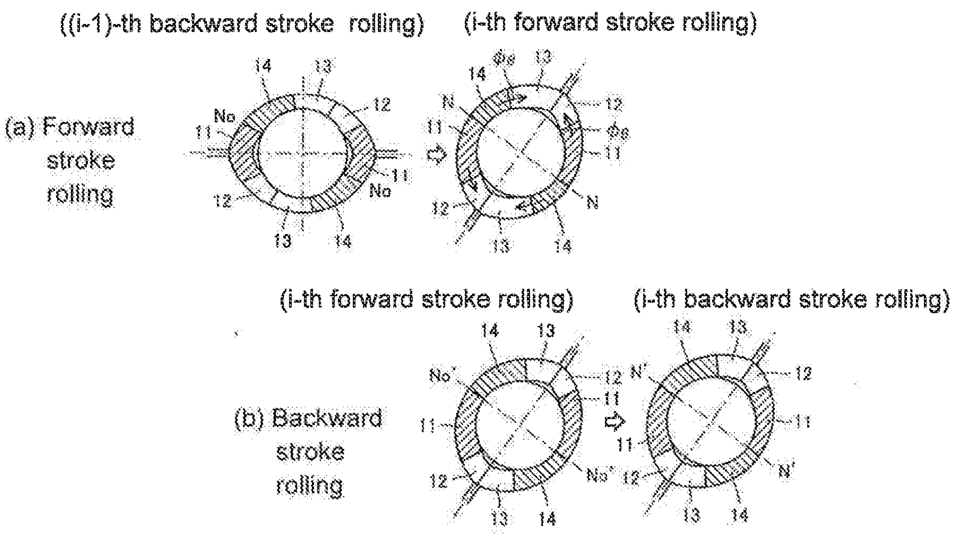
(72) Inventor: **HAYASHI Chihiro**
Osaka-shi
Osaka 541-0041 (JP)

(74) Representative: **Zimmermann & Partner**
Josephspitalstr. 15
80331 München (DE)

(54) PROCESS FOR PRODUCTION OF SEAMLESS METAL PIPE BY COLD ROLLING

(57) In cold rolling of a seamless metallic tube with a cold pilger mill, when a reduction ratio of an outside diameter becomes excessive in comparison to a reduction ratio of a wall thickness, strain in a circumferential direction on flange regions becomes excessive. As a result, compressive stress in a circumferential direction becomes excessive, so that wrinkle imperfections are generated inside a tube and folded on groove bottom regions to become folded defects. This process is repeated to be developed into inside defects. When a hollow shell is produced by the Mannesmann-mandrel process instead of the extrusion process, inside wrinkle imperfections are generated with a sizing mill (a stretch reducer or a sizer) at a stage of hollow shell. Since the inside wrinkle imperfections further grow in cold rolling, it is necessary to pay attention thereto. In consideration of these, (a reduction ratio of an outside diameter/a reduction ratio of a wall thickness both in a cold pilger mill) is set to not more than 1/2. It is, thereby, possible to obtain a high-quality seamless metallic tube, inside defects thereof being suppressed, produced by cold rolling.

FIG. 4



EP 2 390 016 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a cold rolling method for a seamless metallic tube, particularly to a method for producing a high-quality seamless metallic tube by cold rolling for the purpose of ensuring inside-surface quality of high-grade specialty tubes from a viewpoint of suppressing wrinkle imperfections on the inside surface.

BACKGROUND ART

[0002] When a seamless metallic tube does not satisfy specific requirements in quality, strength, or dimensional accuracy in an as-hot-finished condition, it is subjected to a cold working process. Commonly known cold working processes are a cold drawing method with a die and a plug or a mandrel bar, and a cold rolling method with a cold pilger mill.

[0003] Since available reduction rate for tube material is extremely high in cold rolling with a cold pilger mill, the cold rolling has advantages as follows: about ten-times elongation is possible by rolling; an excellent effect on correcting eccentric wall thickness of tube can be exhibited; a diameter-reducing process is not required; and no yield loss is generated.

[0004] Meanwhile, the cold rolling with a cold pilger mill has a drawback of extremely low productivity in comparison to the cold drawing method. The cold rolling with a cold pilger mill is, therefore, mainly suitable for cold working of high-grade specialty tube such as stainless steel tube and high-alloy steel tube that requires expensive raw materials and costly intermediate treatments,.

[0005] Fig. 1 is a view for illustrating a mechanism of the cold rolling with a cold pilger mill. In a cold rolling method with a cold pilger mill, a hollow shell 1 is processed between a pair of rolls 2 and a tapered mandrel bar 4 to perform a diameter-reducing rolling for the hollow shell 1, so as to obtain a rolled tube 5. Each roll 2 has a circumferential length-wise tapered groove caliber 3 decreasing gradually in diameter along the circumferential length. The tapered mandrel bar 4 decreases gradually in diameter along a longitudinal direction.

[0006] That is, the groove caliber 3 is formed along a circumference of each of paired rolls 2 of the cold pilger mill, and the groove caliber becomes narrower/smaller with the progress of rotation of rolls 2. The rolls 2 repeat forward and backward strokes along the tapered mandrel bar while being rotated by driven roll shafts 2s so that the hollow shell 1 is rolled between the rolls 2 and the mandrel bar 4 to perform a diameter-reducing rolling of the hollow shell 1 (see Non Patent Literature 1, for example).

[0007] Fig. 2 is an explanatory view showing a working principle of cold rolling with a cold pilger mill. Fig. 2(a) shows a working state at a start point of a forward stroke, and Fig. 2(b) shows a working state at a start point of a backward stroke. As shown in Fig. 2, in the cold pilger mill, according to an outside diameter and a wall thickness (do and to in the figure) of a hollow shell 1 and an outside diameter and a wall thickness (t and d in the figure) of a product, selectively adopted are a pair of rolls 2 each having a tapered groove caliber 3 which decreases gradually in diameter from an engaging entry side of the rolls toward a finishing exit side thereof, and a tapered mandrel bar 4 which decreases also gradually in diameter from an engaging entry side toward a finishing exit side, and forward and backward strokes are repeated to reduce a wall thickness of the hollow shell 1 while reducing a diameter thereof.

[0008] The hollow shell 1 is turned by about 60° and is given a feed of about 5 to 15 mm at a start point of the forward stroke in reciprocation motion of the cold pilger mill, so that a new portion of the hollow shell is rolled, which is repeated.

[0009] There are two types of cold pilger mills: a rolling mill developed by "MANNESMANN-DEMAG, the rolling mill for reducing wall thickness in both forward and backward strokes; and a rolling mill developed by BLAWKNOX, the rolling mill for reducing wall thickness only in a forward stroke. The former is commonly used for rolling stainless steel tube, high-alloy metallic tube, or zirconium tube, while the latter is used for rolling an aluminum tube, aluminum-alloy tube, copper tube, and copper-alloy tube.

CITATION LIST

NON PATENT LITERATURE

[NON PATENT LITERATURE 1]

[0010] The Iron and Steel Institute of Japan, "3rd Edition Iron and Steel Handbook, Vol. III (2), Steel Bars/Steel Pipe/ Facilities Commonly Used for Rolling", November 20, 1980, Pages 1183-1189

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0011] Since characteristic of high-quality is strongly demanded for high-grade specialty tube subjected to cold rolling with a cold pilger mill, it is necessary to suppress generation of inside-surface defects resulting from inside-surface wrinkle imperfections on a tube as a product after the cold rolling. There, however, has heretofore been no proposal on a method for producing a high-quality seamless steel tube, wherein inside-surface defects are inhibited from occurring in the cold rolling with a cold pilger mill.

[0012] The present invention is achieved in view of the above problem, and an object of the present invention is to propose a method for producing a high-quality seamless steel tube by the cold rolling with a cold pilger mill.

[0013] Although a cold pilger mill performing rolling in both forward and backward strokes (MANNESMANN-DEMAG) will be described for the explanation of the present invention, objects of the present invention are not limited to this type but can be applied to a cold pilger mill reducing wall thickness only in a forward stroke (BLAWKNOX).

SOLUTION TO PROBLEM

[0014] In order to solve the above problem, the present inventor found from various examinations the following. That is, in cold rolling of a seamless metallic tube with a cold pilger mill, when a reduction rate of an outside diameter becomes excessive in comparison to a reduction rate of a wall thickness, circumferential compressive stress imposed on a hollow shell becomes excessive, and wrinkle imperfections are, hence, easily generated on the tube inside surface.

[0015] Furthermore, when a hollow shell is produced by the Mannesmann-mandrel mill process instead of the Ugine-Sejournet extrusion process, inside wrinkle imperfections may be generated with a sizing mill (a stretch reducer or a sizer) at a stage of hollow shell. The inside wrinkle imperfections generated at the stage of hollow shell significantly influence quality of a high-grade specialty tube subjected to the cold rolling with a cold pilger mill.

[0016] The present invention is completed based on the above knowledge, and a gist thereof is methods of the following (1) and (2) each for producing a seamless metallic tube by cold rolling.

[0017] (1) A method for producing a seamless metallic tube by cold rolling with a cold pilger mill, comprising the steps of: when elongating a hollow shell in such a manner that an outside diameter thereof is reduced while reducing a wall thickness thereof, according to outside diameters and wall thicknesses of the hollow shell and a rolled tube as a product, selectively using a pair of rolls and a tapered mandrel, the rolls each having a tapered groove caliber which decreases gradually in diameter from an engaging entry side of roll toward a finishing exit side thereof, the tapered mandrel bar decreasing also gradually in diameter from an engaging entry side toward a finishing exit side; and setting a reduction rate Rd of the outside diameter to not more than one-half of a reduction rate Rt of the wall thickness.

[0018] The reduction rate Rd of outside diameter and the reduction rate Rt of wall thickness are calculated by following expressions (a) and (b):

$$Rd = \{1 - (d/do)\} \times 100\ (\%) \qquad \ldots (a)$$

$$Rt = \{1 - (t/to)\} \times 100\ (\%) \qquad \ldots (b)$$

wherein

do: outside diameter of hollow shell, d: finishing outside diameter, to: wall thickness of hollow shell, and t: finishing wall thickness.

[0019] (2) In the method of (1) for producing a seamless metallic tube by cold rolling, it is preferable to use a hollow shell subjected to a hot reducing mill process with a stretch reducer under the condition that a reduction rate of outside diameter is not more than 77%. Or it is preferable to use a hollow shell subjected to a hot reducing mill process with a sizer under the condition that a reduction rate of outside diameter is not more than 33%.

ADVANTAGEOUS EFFECTS OF INVENTION

[0020] According to the method of the present invention for producing a seamless metallic tube by cold rolling, it is possible to suppress generation of inside-surface defects resulting from inside-surface wrinkle imperfections by improving a working balance between a reduction rate Rd of outside diameter and a reduction rate Rt of wall thickness at the time of the elongation-rolling which accompanies the reduction of the diameter while reducing the wall thickness. It is, therefore, possible to ensure high-quality for the product after cold rolling.

[0021] Furthermore, when a hollow shell is produced by the Mannesmann-mandrel mill process, it is possible to further improve product quality after cold rolling by limiting a reduction rate of outside diameter in a sizing mill (a stretch reducer or a sizer).

BRIEF DESCRIPTION OF THE DRAWINGS

[0022]

[Fig. 1] A view for illustrating a mechanism of the cold rolling with a cold pilger mill.
[Fig. 2] An explanatory view showing a working principle of the cold rolling with a cold pilger mill, Fig. 2(a) shows a working state at a start point of a forward stroke, and
Fig. 2(b) shows a working state at a start point of a backward stroke.
[Fig. 3] A view showing a divided model of a cross-section of a tube rolled with a cold pilger mill.
[Fig. 4] A view showing deformation behaviors of a cross-section of a tube rolled with a cold pilger mill.
[Fig.5] A view for illustrating one example of production steps in the Mannesmann-mandrel mill process for hot-producing seamless steel tube.

DESCRIPTION OF EMBODIMENTS

[0023] Fig. 3 is a view showing a segmentation model of a cross-section of an in-process tube rolled during rolling with a cold pilger mill. The cross-section of tube can be segmented into groove bottom regions 11, 14 and flange regions 12, 13 based on whether or not the inner surface of tube 1 is in contact with a mandrel bar 4. The groove bottom regions 11, 14 are elongated by being subjected to a wall thickness reduction work by means of the rolls and the mandrel bar 4, and the flange regions 12, 13 are deformed by being pulled by the elongation of the groove bottom regions. That is, metals of the groove bottom regions 11, 14 are deformed under external pressure, internal pressure, and axial compression force, and metals of the flange regions 12, 13 are deformed under external force and axial force. of tension

[0024] Fig. 4 is a view showing deformation behaviors with respect to the cross-section of tube during rolling with a cold pilger mill. Fig. 4(a) shows a deformation behavior during rolling in a forward stroke (forward rolling), and Fig. 4(b) shows a deformation behavior during rolling in a backward stroke (backward rolling). The deformation behaviors shown in Fig. 4 are based on a working pattern in which the tube 1 is turned only in the forward stroke rolling and not turned in the backward stroke rolling. That is, when seen from tube side, the rolls are turned relative to the in-process tube to be repositioned only during the forward stroke but not relatively turned during the backward stroke.

[0025] As shown in Figs. 4(a) and 4(b), in a type of cold pilger mill performing rolling in both forward and backward strokes (MANNESMANN-DEMAG), A turn of 60°is basically adopted. Deformation of the cross-section of tube is, thus, not symmetrical but asymmetrical to a horizontal axis and a vertical axis of a groove caliber. In deformation behaviors shown in Fig. 4, segments 11 and 14 indicate the groove bottom regions, and segments 12 and 13 indicate the flange regions in the i-th forward stroke rolling.

[0026] In the deformation behaviors shown in Fig. 4, when a reduction rate Rd of outside diameter is excessively large relative to a reduction rate Rt of wall thickness, compressive strain $\varphi\theta$ in a circumferential direction on the flange regions is increased. As a result, compressive stress $\sigma\theta$ in a circumferential direction (not shown) becomes excessive, so that inside-surface wrinkle imperfections are generated and folded on the groove bottom regions. This process is repeated to be developed into inside-surface defects, resulting in deterioration of inside-surface quality.

[0027] In the production of a specialty tube which requires a high level of quality characteristic, a ratio of the reduction rate Rd of outside diameter to the reduction rate Rt of wall thickness determines quality of product. Furthermore, when a hollow shell to be processed with a cold pilger mill is produced by the Mannesmann-mandrel mill process instead of the hot extrusion (Ugine-Sejournet extrusion) process, the hollow shell includes inside-surface wrinkle imperfections generated in a hot reducing mill process. The inside-surface wrinkle imperfections further encourages the development thereof and affects the cold rolling process.

[0028] Fig. 5 is a view for illustrating one example of production steps in the Mannesmann-mandrel mill process for hot-producing seamless steel tube. In this process, a solid round billet 21 heated to a predetermined temperature serves as a starting material to be rolled. This round billet 21 is fed to a piercing mill 23, and a central portion thereof is pierced so as to produce a hollow piece (hollow shell) 22. Next, the produced hollow piece 22 is directly fed to a successive elongating device, which is a mandrel mill 24, to be elongated, so as to obtain a hollow shell 22.

[0029] At the time of the elongation rolling with the mandrel mill 24, a material temperature of the hollow shell 22 is lowered with a mandrel bar 24b inserted into the inside of the hollow shell and rolling rolls 24r for constraining outer surface of the hollow shell. Therefore, the hollow shell 22 rolled in the mandrel mill 24 is then placed into a re-heating furnace 25 to be re-heated. After that, the hollow shell goes through a sizing mill such as a stretch reducer 26 or a sizer (not shown) and becomes a hot-rolled seamless steel tube. When a temperature drop in the mandrel mill is small, the re-heating furnace is not required.

[0030] However, in the stretch reducer or the sizer for performing the sizing mill process in the above Mannesmann-mandrel mill process, the hollow shell 22 goes through rolling rolls 26r to be finished by a reducing mill process for an outside diameter without using the inside surface constraining tool such as a mandrel bar. Wrinkle imperfections are, thus, easily generated on the inner surface of the hot-finished steel tube.

[0031] The present inventor, therefore, performed rolling tests in which, as test specimens, not only hollow shells hot-extruded but also hollow shells subjected to a reducing mill process with a stretch reducer and a sizer are used. The rolling tests varying in reduction rate of outside diameter in a reducing mill process and varying in reduction rates of outside diameter along with wall thickness in cold rolling are performed. Macroscopic structure observations for the specimens are conducted to investigate conditions for suppressing wrinkle imperfections.

[0032] As described above, in the cold rolling of a seamless metallic tube with a cold pilger mill, when a reduction rate of outside diameter becomes excessive in comparison to a reduction rate of wall thickness, strain in a circumferential direction on the flange regions becomes excessive. As a result, compressive stress in a circumferential direction becomes excessive, so that wrinkle imperfections are generated on the inside surface of tube and folded on the groove bottom regions to become folded imperfections. This process is repeated to be developed into detrimental inside surface defects.

[0033] As a result of the above investigation, when a hollow shell is produced by the Mannesmann-mandrel mill process instead of the hot extrusion process, inside-surface wrinkle imperfections may be generated with a sizing mill (a stretch reducer or a sizer) at a stage of hollow shell. And when these inside-surface wrinkle imperfections are present, the inside wrinkle imperfections further encourage the development thereof in cold rolling, to which attention shall be paid..

[0034] With respect to the method of the present invention for producing a seamless metallic tube by cold rolling, taking into consideration that not only hot-extruded hollow shell but also hollow shell made by a hot sizing mill process are to be used, it is necessary to set a reduction rate of outside diameter to not more than one-half of a reduction rate of wall thickness in a cold pilger mill.

[0035] In the method of the present invention for producing a seamless metallic tube by cold rolling, when a sizing mill process is performed with a stretch reducer, it is preferable to use a hollow shell made by a hot reducing mill process under the condition that a reduction rate of outside diameter is not more than 77%. Or when a sizing mill process is performed with a sizer, it is preferable to use a hollow shell made by a hot reducing mill process under the condition that a reduction rate of outside diameter is not more than 33%.

EXAMPLES

[0036] As test specimens, hollow shells produced by the hot extrusion (Ugine-Sejournet extrusion) process and hollow shells produced by the Mannesmann-mandrel mill process (finished with a stretch reducer and a sizer) are used. Inside-surface quality of product was evaluated for samples that underwent cold working with a cold pilger mill for diameter-reducing rolling.

(Example 1)

[0037] A 25Cr-30Ni-3Mo high-alloy steel tube having an outside diameter of 50.8 mm and a wall thickness of 5.5 mm produced by the hot extrusion process was used as a hollow shell for a test specimen. The hollow shell was rolled with a cold pilger mill to reduce to 38.1 mm in outside diameter and to 2.4 mm in wall thickness. The hollow shell was fed and turned at the start point of each forward stroke. Test conditions are summarized below.

[0038]

Diameter of tapered mandrel bar: dm varying from 39.6 to 33.1 mm (tapered)
Feed in forward stroke: f=8.0 mm
Turn angle in forward stroke: θ=60°
Hollow shell dimension: do x to=50.8 mm x 5.5 mm
Finishing dimension: d x t=38.1 mm x 2.4 mm
Ratio between diameters before and after reduction: d/do=0.75
Elongation ratio: to (do-to)/t (d-t)=2.91
Wall thickness/Outside diameter: t/d=0.063
Reduction rate of outside diameter / Reduction rate of wall thickness:

$$Rd/Rt=0.46<1/2$$

wherein

$$\text{Reduction rate of outside diameter: } Rd=\{1-(d/do)\}\times 100\ (\%)$$

$$\text{Reduction rate of wall thickness: } Rt=\{1-(t/to)\}\times 100\ (\%)$$

[0039] Since no wrinkle imperfections were generated on the hollow shell produced by the extrusion, generation of inside-surface defects resulting from the wrinkle imperfections was extremely few on a product after cold rolling, and satisfactory inside-surface quality was obtained.

(Example 2)

[0040] A 25Cr-30Ni-3Mo high-alloy steel tube having an outside diameter of 48.6 mm and a wall thickness of 6.0 mm produced by the Mannesmann-mandrel mill process with an inclined roll type piercing mill, a mandrel mill, and a stretch reducer was used as a hollow shell for a test specimen. The hollow shell was rolled with a cold pilger mill to reduce to 41.0 mm in outside diameter and to 2.2 mm in wall thickness The reduction rate of outside diameter in the stretch reducer was not more than 77%. Test conditions are summarized below.
[0041]

Diameter of mandrel bar: dm=36.4 mm (without taper)
Feed in forward stroke: f=8.0 mm
Turn angle in forward stroke: θ=60°
Hollow shell dimension: do x to=48.6 mm x 6.0 mm
Finishing dimension: d x t=41.0 mm x 2.2 mm
Ratio between diameters before and after reduction: d/do=0.84
Elongation ratio: to (do-to)/t (d-t)=3.0
Wall thickness/Outside diameter: t/d=0.054
Reduction rate of outside diameter / Reduction rate of wall thickness:

$$Rd/Rt=0.25<1/2$$

wherein

$$\text{Reduction rate of outside diameter: } Rd=\{1-(d/do)\}\times 100\ (\%)$$

$$\text{Reduction rate of wall thickness: } Rt=\{1-(t/to)\}\times 100\ (\%)$$

[0042] While the reduction rate of outside diameter in the stretch reducer was not more than 77%, generation of inside wrinkle imperfections was extremely suppressed since a reducing mill process was performed while imparting maximum inter-stand tensional force by full-stretch setup. Also generation of inside-surface defects resulting from the wrinkle imperfections was, thus, mild on a product after cold rolling, and satisfactory inside-surface quality was obtained.

(Example 3)

[0043] A 25Cr-30Ni-3Mo high-alloy steel tube having an outside diameter of 101.6 mm and a wall thickness of 7.0 mm produced by the Mannesmann-mandrel mill process with an inclined roll type piercing mill, a mandrel mill, and a sizer was used as a hollow shell for a test specimen. The hollow shell was rolled with a cold pilger mill to reduce to 88.9

mm in outside diameter and to 2.8 mm in wall thickness. A reduction rate of outside diameter in the sizer was not more than 33%. Test conditions are summarized below.

[0044]

Diameter of mandrel bar: dm=83.8 mm (without taper)
Feed in forward stroke: f=10.0 mm
Turn angle in forward stroke: θ=60°
Hollow shell dimension: do x to=101.6 mm x 7.0 mm
Finishing dimension: d x t=88.9 mm x 2.8 mm
Ratio between diameters before and after reduction: d/do=0.88
Elongation ratio: to (do-to)/t (d-t)=2.8
Wall thickness/Outside diameter: t/d=0.032
Reduction rate of outside diameter / Reduction rate of wall thickness:

$$Rd/Rt=0.21<1/2$$

wherein

$$\text{Reduction rate of outside diameter: } Rd=\{1-(d/do)\}\times 100\ (\%)$$

$$\text{Reduction rate of wall thickness: } Rt=\{1-(t/to)\}\times 100\ (\%)$$

[0045] Since the reduction rate of outside diameter in the sizer was not more than 33%, which was considerably small in comparison to the reduction rate of outside diameter in case of the stretch reducer, generation of inside-surface wrinkle imperfections was extremely suppressed. Generation of inside-surface defects resulting from the wrinkle imperfections was, thus, mild on a product after cold rolling, and satisfactory inside-surface quality was obtained.

INDUSTRIAL APPLICABILITY

[0046] According to the method of the present invention for producing a seamless metallic tube by cold rolling, it is possible to suppress generation of inside-surface defects resulting from inside wrinkle imperfections by improving a working balance between a reduction rate Rd of outside diameter and a reduction rate Rt of wall thickness at the time of elongation rolling accompanying diameter reduction working while reducing wall thickness. It is, therefore, possible to obtain a high-quality tube as a product after cold rolling.

[0047] Furthermore, when a hollow shell is produced by the Mannesmann-mandrel mill process, it is possible to further improve the product quality after cold rolling by limiting a reduction rate of outside diameter in a sizing mill (a stretch reducer or a sizer). The present invention, thus, can be widely applied as a method for producing a high-quality seamless metallic tube by cold rolling.

REFERENCE SIGNS LIST

[0048]

1: Hollow shell
2: Groove caliber roll
3: Tapered groove caliber
4: Tapered mandrel bar
5: Rolled tube
11, 14: Segment on groove bottom side
12, 13: Segment on flange side
21: Round billet
22: Hollow piece, hollow shell
24: Mandrel mill
25: Re-heating furnace

26: Sizing mill, stretch reducer

Claims

1. A method for producing a seamless metallic tube by cold rolling with a cold pilger mill, **characterized in that**:

   when elongating a hollow shell in such a manner that an outside diameter thereof is reduced while reducing a wall thickness thereof, selectively used are a pair of rolls and a tapered mandrel bar according to outside diameters and wall thicknesses of the hollow shell and a rolled tube as a product, the rolls each having a tapered groove caliber which decreases gradually in diameter from an engaging entry side of roll toward a finishing exit side thereof, the tapered mandrel bar decreasing also gradually in diameter from an engaging entry side toward an finishing exit side; and,
   a reduction rate Rd of outside diameter is set to not more than one-half of a reduction rate Rt of wall thickness, wherein

$$Rd= \{1-(d/do)\} \times 100\ (\%)$$

$$Rt= \{1-(t/to)\} \times 100\ (\%)$$

   do: outside diameter of hollow shell
   d: finishing outside diameter
   to: wall thickness of hollow shell
   t: finishing wall thickness.

2. The method for producing a seamless metallic tube by cold rolling according to claim 1, **characterized in that** used is a hollow shell made by a hot reducing mill process with a stretch reducer under the condition that a reduction rate of outside diameter is not more than 77%.

3. The method for producing a seamless metallic tube by cold rolling according to claim 1, **characterized in that** used is a hollow shell made by a hot reducing mill process with a sizer under the condition that a reduction rate of outside diameter is not more than 33%.

FIG. 1

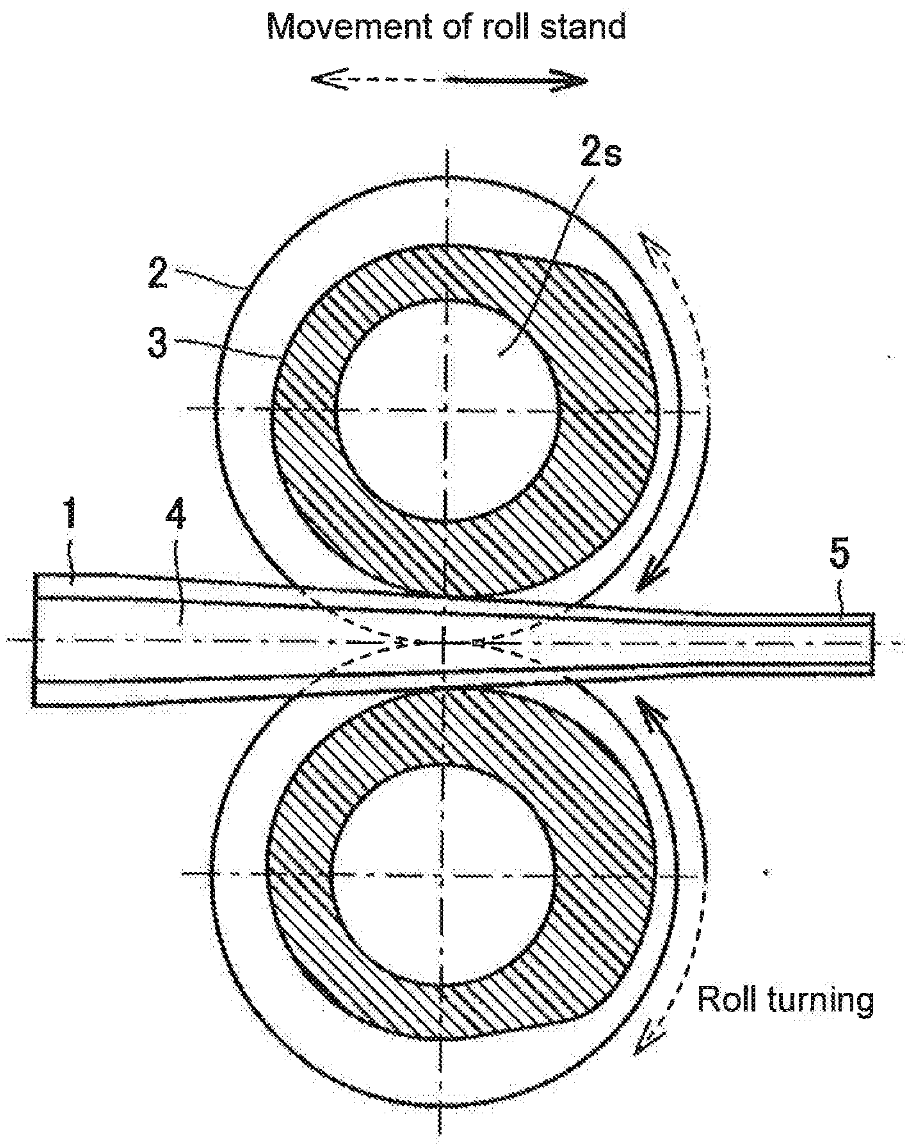


FIG. 2

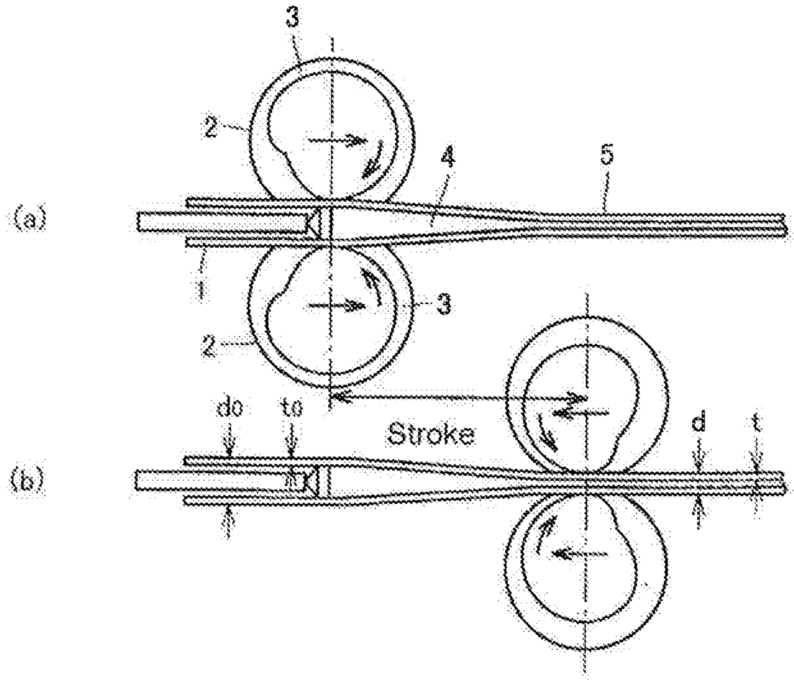


FIG. 3

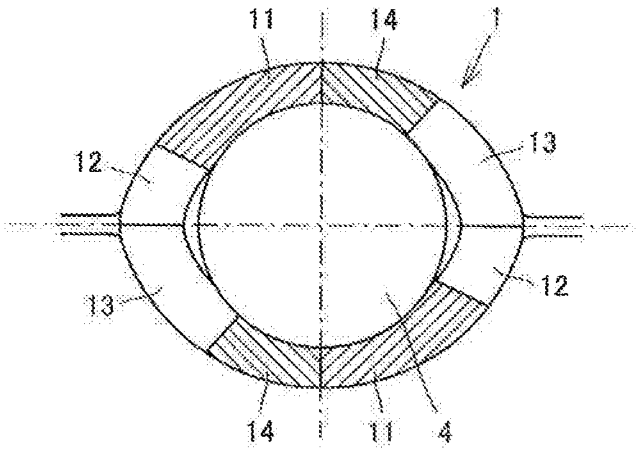


FIG. 4

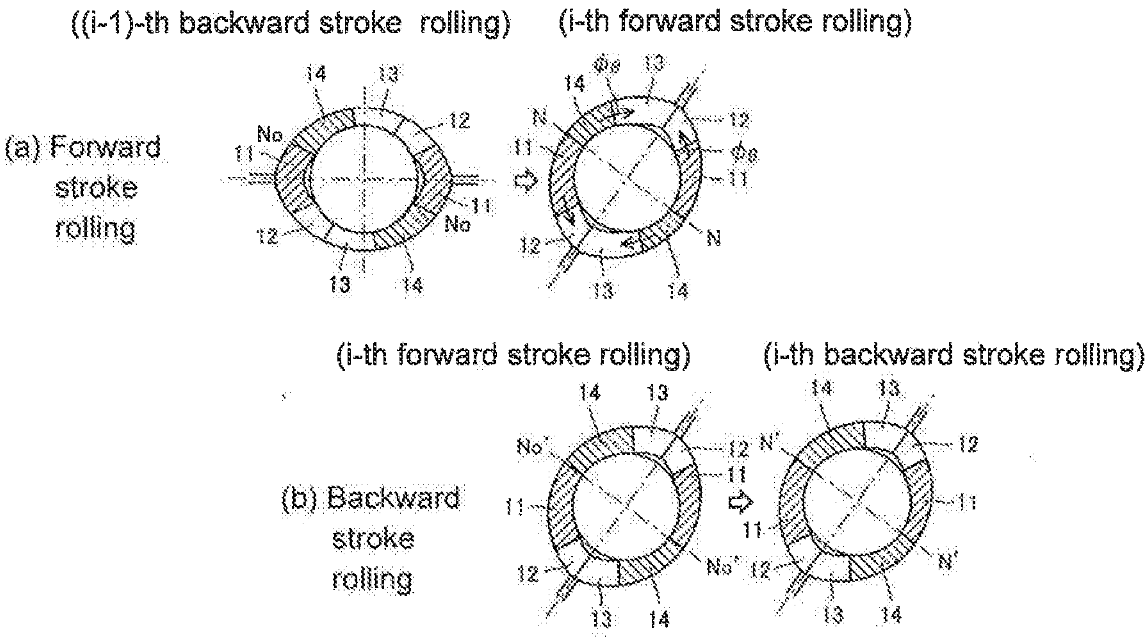
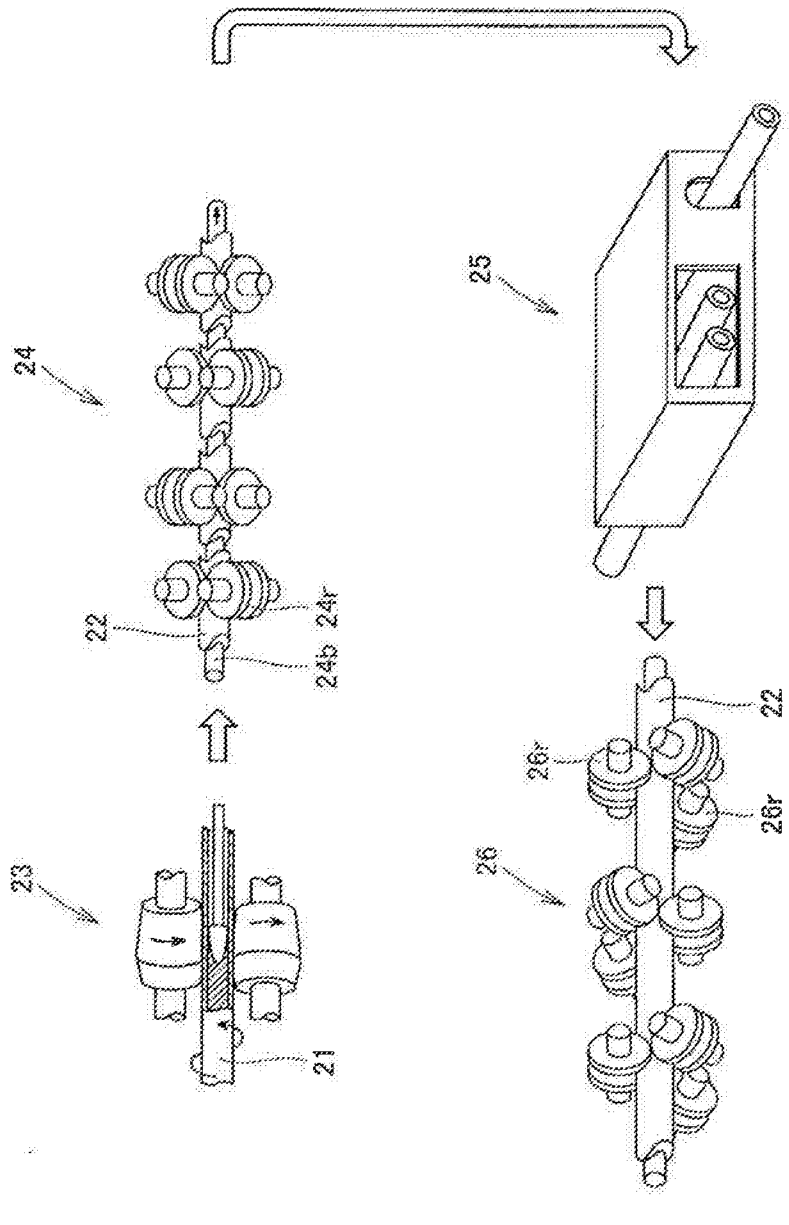

((i-1)-th backward stroke rolling)
(i-th forward stroke rolling)
(a) Forward stroke rolling
(i-th forward stroke rolling)
(i-th backward stroke rolling)
(b) Backward stroke rolling
14
13
12
11
No
N
No'
N'

FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/069823

A. CLASSIFICATION OF SUBJECT MATTER
B21B21/00(2006.01)i, *B21B23/00*(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)
B21B21/00, B21B23/00

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	1996-2010
Kokai Jitsuyo Shinan Koho	1971-2010	Toroku Jitsuyo Shinan Koho	1994-2010

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.
X A	JP 4-127902 A (Sumitomo Metal Industries, Ltd.), 28 April 1992 (28.04.1992), page 3, upper left column, lines 4 to 6 (Family: none)	1 2,3
A	JP 2007-38296 A (Sumitomo Metal Industries, Ltd.), 15 February 2007 (15.02.2007), entire text & US 2006/0288750 A1 & EP 1738839 A2 & CA 2550931 A1	1-3

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

* Special categories of cited documents:
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Date of the actual completion of the international search	Date of mailing of the international search report
28 January, 2010 (28.01.10)	09 February, 2010 (09.02.10)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/069823

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 2003-62604 A (Sanyo Special Steel Co., Ltd.), 05 March 2003 (05.03.2003), entire text (Family: none)	1-3

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REFERENCES CITED IN THE DESCRIPTION

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Non-patent literature cited in the description

- 3rd Edition Iron and Steel Handbook, Vol. III (2), Steel Bars/Steel Pipe/Facilities Commonly Used for Rolling. 20 November 1980, vol. III(2), 1183-1189 **[0010]**