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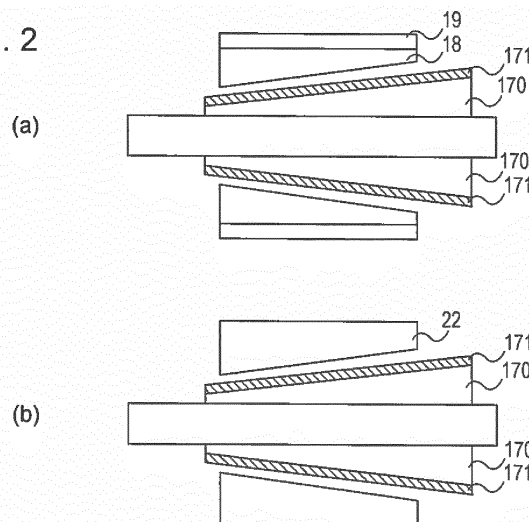
(54) **PIPE EXPANDER**

(57) A pipe expander that can manufacture a steel pipe at low cost is provided.

The pipe expander includes a cone that is fitted around the tip of a draw bar connected to a cylinder and has an outer periphery of which the size changes gradually in the axial direction thereof, and a pipe expansion head outer surface member disposed on the outer periphery of the cone. The cone pulled by the cylinder in

the axial direction radially expands the pipe expansion head outer surface member by wedge action of the cone and the pipe expansion head outer surface member, to expand a steel pipe placed on the outer periphery of the pipe expansion head outer surface member. The cone has a detachable liner on a contact surface thereof with the pipe expansion head outer surface member.

FIG. 2



Description

Technical Field

5 **[0001]** The present invention relates to a pipe expander used for manufacturing a welded pipe such as a UOE steel pipe.

Background Art

10 **[0002]** In general, in the manufacturing of a welded pipe typified by a UOE steel pipe, after the welding of the inner and outer surfaces of the pipe, residual stress due to thermal effect of this welding worsen roundness and straightness of the pipe. Therefore, pipe expansion is performed to remove the residual stress and to correct roundness and straightness.

15 **[0003]** This pipe expansion is described, for example, in Non Patent Literature 1. Fig. 1 (a) and (b) are reproductions of figures disclosed in Non Patent Literature 1. In the pipe expansion process, a pipe expansion head 13 of a mechanical pipe expander 100 is inserted into a steel pipe 1 that has been submerged arc welded from its inner and outer surface sides. As shown in Fig. 1 (b), when a cone 17 of the pipe expansion head 13 is pulled in the axial direction, a jaw 18 is radially expanded by wedge action of the cone 17 and the jaw 18, and a die 19 attached to the outside of the jaw 18 expands the steel pipe 1. A combination of the jaw 18 and the die 19 corresponds to a pipe expansion head outer surface member.

20 **[0004]** In such a pipe expansion process, as shown in Fig. 1 (b), the cone 17 and the jaw 18 slide on sliding surfaces on which both the two contact.

[0005] In recent years, the strength of steel pipes 1 has become higher. Therefore, when the cone 17 is pulled in the axial direction, excessive force is applied thereto, and the surface pressure on the sliding surfaces between the cone 17 and the jaw 18 also becomes excessive, to cause seizure on the sliding surfaces of the cone 17 and the jaw 18. Accordingly, a problem of disabling pipe expansion often arises, to require the maintenance of the sliding surfaces of the cone 17 and the jaw 18.

25 **[0006]** To solve this problem, in Patent Literature 1, it is proposed to form a hardened layer having a depth of 0.05 to 1.5 mm on the surface layer of a cone by nitriding treatment. In Patent Literature 2, it is proposed to set the hardness of segments, which correspond to the above jaw, at HRC 45 to 52, and to apply nitrosulphurizing treatment on its surface. In Patent Literature 3, it is proposed to supply lubricating oil to the sliding surfaces of the cone 17 and the jaw 18 to reduce seizure between the sliding surfaces of the cone 17 and the jaw 18.

Citation List

35 Patent Literature

[0007]

40 PTL 1: Japanese Unexamined Patent Application Publication No. 01-299723
PTL 2: Japanese Unexamined Patent Application Publication No. 05-195158
PTL 3: Japanese Unexamined Patent Application Publication No. 2007-284519

Non Patent Literature

45 **[0008]** NPL 1: Tekko Binran Vol. 3 (2), 4th edition, section 12.4.6

Summary of Invention

Technical Problem

50 **[0009]** However, in Patent Literature 1 and Patent Literature 2, the relationship between the cone and the segments (jaw) is not at all studied; therefore, seizure of the sliding part of the sliding surfaces cannot be sufficiently prevented. The seizure of the sliding part of the sliding surfaces cannot be sufficiently prevented only by supplying lubricating oil as in Patent Literature 3. When seizure occurs in the sliding part, the cone needs to be replaced, and the replacement of the cone, which is expensive, significantly increases the manufacturing cost of the steel pipe.

55 **[0010]** The present invention has been made to solve such a problem, and it is an object of the present invention to provide a pipe expander that can manufacture a steel pipe at low cost.

Solution to Problem

[0011] The inventors have conducted intense studies to attain the above object. As a result, the inventors have found that the above problem can be solved by a configuration in which a cone has a liner on a contact surface thereof with a jaw, to complete the present invention. More specifically, the present invention provides the followings.

[1] A pipe expander comprising a cone that is fitted around the tip of a draw bar connected to a cylinder and has an outer periphery of which the size changes gradually in the axial direction thereof, and a pipe expansion head outer surface member disposed on the outer periphery of the cone, wherein the cone pulled by the cylinder in the axial direction radially expands the pipe expansion head outer surface member by wedge action of the cone and the pipe expansion head outer surface member, to expand a steel pipe placed on the outer periphery of the pipe expansion head outer surface member, and wherein the cone has a detachable liner on a contact surface thereof with the pipe expansion head outer surface member.

[2] The pipe expander according to [1], wherein on the contact surfaces of the liner and the pipe expansion head outer surface member, there is a difference in hardness between the liner and the pipe expansion head outer surface member.

[3] The pipe expander according to [2], wherein the difference in hardness is 20 to 50 HS.

[4] The pipe expander according to [2] or [3], wherein in the contact surfaces of the liner and the pipe expansion head outer surface member, the hardness of the softer member is 30 HS or more.

[5] The pipe expander according to any one of [2] to [4], wherein the softer member is the liner.

[6] The pipe expander according to any one of [1] to [5], wherein the liner is made of copper alloy.

[0012] In this description, HS represents hardness HS according to Shore hardness test specified in JIS Z 2246. Advantageous Effects of Invention

[0013] The cone of the present invention has the detachable liner on the contact surface thereof with the pipe expansion head outer surface member. Therefore, when seizure occurs in the liner, it is necessary to replace not the whole cone but the liner only. Therefore, according to the present invention, an increase in manufacturing cost of the steel pipe due to the replacement of the cone can be suppressed.

Brief Description of Drawings

[0014]

[Fig. 1] Fig. 1 includes schematic views showing an example of a pipe expander, in which (a) shows the configuration of a pipe expander, and (b) shows the configuration of a pipe expansion head.

[Fig. 2] Fig. 2 includes schematic views showing an example of a pipe expansion head of a pipe expander of the present invention, in which (a) shows a case of a pipe expansion head outer surface member consisting of a jaw and a die, and (b) shows a case of a pipe expansion head outer surface member in which a jaw and a die are integrated.

[Fig. 3] Fig. 3 includes schematic views showing an example of a cone disposed in the pipe expander of the present invention, in which (a) shows a cross-section in a direction perpendicular to the axis, and (b) shows an axial cross-section.

[Fig. 4] Fig. 4 is a diagram showing the relationship between the difference in hardness between the liners and the jaw and the coefficient of friction between the liners and the jaw.

Description of Embodiments

[0015] Embodiments of the present invention will be described below. It should be noted that present invention is not limited to the following embodiments.

First Embodiment

[0016] Fig. 1 includes schematic views showing an example of a pipe expander. Fig. 1 (a) shows the configuration of a pipe expander, and (b) shows the configuration of a pipe expansion head.

[0017] Fig. 2 includes schematic views showing an example of a pipe expansion head of a pipe expander of the present invention. Fig. 2 (a) shows a case of a pipe expansion head outer surface member consisting of a jaw and a die, and (b) shows a case of a pipe expansion head outer surface member in which a jaw and a die are integrated.

[0018] Fig. 3 includes schematic views showing an example of a cone disposed in the pipe expander of the present invention.

[0019] As shown in Fig. 1 (a), the pipe expander 100 includes a pipe expander main body 14, an axial infeed 15, and a cross-feed 16.

[0020] The pipe expander main body 14 includes a cylinder 11, a horn 12, and a pipe expansion head 13.

[0021] The cross-feed 16 transports a steel pipe 1 in walking beam fashion, in a direction perpendicular to the paper plane. The axial infeed 15 pushes the steel pipe 1 transported by the cross-feed 16, toward the pipe expander main body 14.

[0022] By transporting the steel pipe 1 toward the pipe expander main body 14, the pipe expansion head 13 is inserted into the steel pipe 1. The cylinder 11 pulls the pipe expansion head 13 provided at the tip of the horn 12, in the axial direction. The outer periphery of the pipe expansion head 13 expands radially, and thereby expands the diameter of the steel pipe 1 from the inside.

[0023] As shown in Fig. 1 (b), the pipe expansion head 13 includes a cone 17, a jaw 18, and a die 19. The cone 17 is fitted around the tip of a draw bar 21 connected to the cylinder 11. The size of the outer periphery of the cone 17 changes gradually in the axial direction. "The size of the outer periphery changes gradually" means that the shape is a tapered shape. For example, the cone 17 may have a truncated pyramid shape. By elongating and/or contracting the cylinder 11, the cone 17 is moved in the axial direction. A combination of the jaw 18 and the die 19 corresponds to a pipe expansion head outer surface member.

[0024] The jaw 18 consists of a plurality of segments, and is formed by assembling the plurality of segments, into a tubular shape. The cone 17 is disposed inside the tubular jaw 18. The inside of the jaw 18 is formed in a shape conforming with the outer periphery of the cone 17, and is configured so as to be slidable on the outer periphery of the cone 17. In this description, the sliding surfaces of the cone 17 and the jaw 18 are also referred to as sliding surfaces.

[0025] The die 19 consists of a plurality of segments, and is provided on the outer periphery of the jaw 18.

[0026] A lubricating oil supply pipe 20 supplies lubricating oil to the sliding surfaces of the cone 17 and the jaw 18.

[0027] In the thus configured pipe expander 100, the cone 17 is moved in the axial direction by the elongation and/or contraction of the cylinder 11, and the cone 17 and the jaw 18 thereby run on each other on the sliding surfaces (wedge action). The die 19 provided on the outer periphery of the jaw 18 is thereby expanded radially. Since the steel pipe 1 is fitted on the outer periphery of the die 19, by radially expanding the die 19, the steel pipe 1 is expanded from the inside, and the diameter expansion of the steel pipe 1 is performed.

[0028] In a conventional pipe expander, on the sliding surfaces of the cone 17 and the jaw 18, seizure occurs on the cone 17. The seizure on the surface of the cone 17 necessitates replacement of the cone 17. Because the cone 17 is expensive, the replacement of the cone 17 significantly raises the manufacturing cost of the steel pipe.

[0029] Therefore, the present invention uses a configuration in which the cone 17 has detachable liners 171 on the surface thereof in contact with the jaw 18.

[0030] The pipe expander of the present invention will be described below. The configuration of the pipe expander of the present invention is similar to that of the pipe expander shown in Fig. 1. Therefore, the pipe expander of the present invention will be described, using the reference signs described in Fig. 1, with reference to Figs. 2 and 3.

[0031] As shown in Figs. 2 and 3, the cone 17 of the pipe expander 100 of the present invention includes a cone main body 170, liners 171, and bolts 172 for fixing the liners 171 to the cone main body 170.

[0032] In the cone 17 shown in Figs. 2 and 3, the outer surface of the cone main body 170 is tapered along the axial direction. As shown in Fig. 3 (b), the axial cross-sectional shape of the cone main body 170 is a regular decagon. Each side of the regular decagon is one segment 1700, and the cone main body 170 is formed by ten segments 1700. As shown in Fig. 3 (b), a groove 1701 extending in the axial direction of the cone 17 is formed in a surface of each segment 1700 on the outer periphery of the cone 17. The groove 1701 is deepest in the center and has stepped surfaces 1701A and 1701B at both ends.

[0033] In the cone 17 shown in Figs. 2 and 3, the liners 171 are plate-like members extending in the axial direction of the cone 17, and two pieces of the liners 171 are fixed to each segment 1700 of the cone main body 170. In the cone 17 shown in Figs. 2 and 3, the liners 171 are fixed with the bolts 172, along the stepped surfaces 1701A and 1701B. The liners 171 are detachable by the bolts 172.

[0034] In the cone 17 shown in Figs. 2 and 3, the bolts 172 may be fixing devices with which the liners 171 can be detachably fixed to the cone main body 170, and are not limited to bolts 172.

[0035] In the present invention, the liners 171 may not exist on the entire contact surface of the cone 17 with the jaw 18. If no problem due to seizure arises in the cone 17, there may be regions in which the liners 171 do not exist partially on the contact surface.

[0036] The advantageous effects of the pipe expander 100 of the first embodiment will be described.

[0037] The cone 17 of the pipe expander 100 has liners 171 on a contact surface thereof with the jaw 18. Therefore, during the use of the pipe expander 100, the contact surfaces of the liners 171 and the jaw 18 are sliding surfaces. If the sliding on the sliding surfaces causes seizure on the surfaces of the liners 171, it is only necessary to replace the liners 171. Therefore, compared to the case where the whole cone 17 is replaced, an increase in cost can be suppressed.

[0038] In particular, it is only necessary to replace only the liners 171 in which seizure occurs, and therefore the cost

can be further reduced.

Second Embodiment

[0039] In a pipe expander of a second embodiment, the same reference signs will be used to designate the same components as those of the pipe expander 100 of the first embodiment. The pipe expander 100 of the second embodiment is formed of the same members as those of the pipe expander 100 of the first embodiment, and differs from the pipe expander 100 of the first embodiment in that the hardness of the liners 171 and the hardness of the jaw 18 are adjusted within a certain range. In the following description, the description of the same parts as those of the expander 100 of the first embodiment will be omitted.

[0040] In the pipe expander 100 of the second embodiment, in the contact surfaces of the liner 171 and the jaw 18, there is a difference in hardness between the liner 171 and the jaw 18. Shore hardness test specified in JIS Z 2246 may be used for the measurement of hardness.

[0041] The above difference in hardness is preferably 20 to 50 HS.

[0042] In the contact surfaces of the liners 171 and the jaw 18, the hardness of the softer member is preferably 30 HS or more.

[0043] It is preferable that the softer member be the liners 171.

[0044] The advantageous effects of the pipe expander 100 of the second embodiment will be described.

[0045] By providing a difference in hardness between the liners 171 and the jaw 18, the member having a smaller hardness (softer member) can be caused to wear, the surface pressure on the contact surfaces of the liners 171 and the jaw 18 can be reduced, and seizure of the sliding part of the liners 171 and the jaw 18 can be reduced. As a result, the frequency of replacement of the liners 171 can be reduced.

[0046] Fig. 4 is a diagram showing the relationship between the difference in hardness between the liners 171 and the jaw 18 and the coefficient of friction between the liners 171 and the jaw 18. The difference in hardness HS of the horizontal axis of Fig. 4 is a value obtained by subtracting the hardness of the liners 171 from the hardness of the jaw 18. The coefficient of friction between the liners 171 and the jaw 18 is shown for the case where the hardness of the liners 171 is set to 40 HS and the hardness of the jaw 18 is changed from 33 to 95 HS.

[0047] From Fig. 4, it can be seen that when the difference in hardness between the liners 171 and the jaw 18 is 20 to 50 HS, the coefficient of friction between the liners 171 and the jaw 18 is smaller. When the coefficient of friction is small, seizure in the liners 171 and the jaw 18 can be prevented from occurring.

[0048] Therefore, if the above difference in hardness is adjusted within a range of 20 to 50 HS, the frequency of replacement of the liners 171 can be further reduced.

[0049] When the hardness of the softer member is 30 HS or more, trouble due to too much deformation of the softer member is less likely to occur. That is, when the hardness of the softer member is 30 HS or more, a predetermined shape of the member can be sufficiently retained. The hardness of the softer member is preferably 40 HS or more.

[0050] It is preferable that the softer member be the liners 171. The liners 171 have many corner parts or the like compared to the jaw 18, and seizure is likely to originate in these parts. Therefore, by making the liners 171 softer, and promoting the wear of the liners 171, this seizure can be reduced.

Modification

[0051] In the present invention, the liners 171 are preferably made of copper alloy. Copper alloy containing 55% to 96% mass fraction (mass%) copper is preferable as copper alloy. Pb, Fe, Sn, Zn, Al, Mn, Ni, P, and so forth may be contained as components other than Cu. In particular, aluminum bronze is preferable as copper alloy. Since, as described above, it is preferable that the difference in hardness between the liner 171 and the jaw 18 be 20 to 50 HS, and the liners 171 be softer, it is preferable to make the jaw 18 of a material having a hardness of 50 to 80 HS, to the hardness 30 HS of aluminum bronze.

[0052] By making the liners 171 of copper alloy such as aluminum bronze, and particularly, providing the jaw 18 with a difference in hardness from 20 HS to 50 HS relative to the liners 171, the member having a smaller hardness (aluminum bronze) can be caused to wear, the surface pressure on the contact surfaces of the liner 171 and the jaw 18 can be reduced, and seizure of the sliding part of the liners 171 and the jaw 18 can be reduced. As a result, the frequency of replacement of the liners 171 can be further reduced.

[0053] The conventional knowledge is that the likelihood of seizure of two kinds of metals sliding on each other is low when a system of complete solid solubility is not formed in the liquid phase in the binary system equilibrium diagram of the two metals. Ag, Cd, Pb, and so forth are known as metals that do not form a system of complete solid solubility with steel in the liquid phase. These metals, or alloys consisting mainly of these metals are difficult to use industrially from a viewpoint of cost and environmental issues. On the other hand, Al, Cr, Mn, Fe, Ni, and so forth, which are known as metals that form a system of complete solid solubility with steel in the liquid phase, are prone to seizure with steel. Cu

is also known as a metal that forms a system of complete solid solubility with steel in the liquid phase. As a result of study by the inventors, it turned out that, in the case of alloy containing Cu, that is, copper alloy, particularly aluminum bronze, seizure is less likely to occur when it slide on steel. The mechanism by which seizure in the sliding part is reduced by making the liners 171 of copper alloy, is not exactly clear. In this regard, the present inventors infer that the fact that the Cu solid solubility limit in the solid phase Fe is small, and solid phase Fe and solid phase Cu are likely to exist separately in the solid phase, contributes to the reduction of seizure of the sliding part. It is inferred that, among copper alloys, particularly aluminum bronze is preferable because of a similar mechanism.

[0054] Aluminum bronze herein means a copper alloy consisting mainly of Cu: 78.0 to 92.5%, Al: 6.0 to 11.0%, Fe: 1.5 to 5.0%, Mn: 2.0% or less, corresponding to alloy Nos. C6140, C6161, and C6280 described in JIS H 3100, alloy Nos. C6161, C6191, and C6241 described in JIS H 3250, and so forth. Other than aluminum bronze, various copper alloys containing from 55% to 96% Cu, described in JIS H 3100 and JIS H 3250, such as tin bearing brass of alloy No. C4250 described in JIS H 3100, can be used.

[0055] Although, as described above, the present invention has been described with regard to the case where a pipe expansion head outer surface member consists of a jaw 18 and a die 19, the same working effects can be obtained in the case of a pipe expansion head outer surface member 22 in which a jaw 18 and a die 19 are integrated, such as that shown in Fig. 2 (b).

EXAMPLE 1

[0056] The appearance, the presence or absence of seizure and the presence or absence of wear, of the sliding surfaces of the liners 171 and the jaw 18 in the case where, as the present invention example, in the expansion of a welded pipe, the hardness of the liners 171 in Figs. 2 and 3 was set to 40 HS, and the hardness of the jaw 18 was set to 40 HS, 60 HS, and 80 HS, was examined. The result is shown in Table 1.

[0057] When the hardness of the jaw 18 was 40 HS (the difference in hardness was 0), no wear was observed in the liners 171 and the jaw 18 and seizure was observed after 1000 times of pipe expansion. The liners 171 were replaced with new ones, and the pipe expansion became smooth (No. 1 in Table 1).

[0058] When the hardness of the jaw 18 was 60 HS (the difference in hardness was 20 HS), slight wear was observed in the liners 171 after 3000 times of pipe expansion, and no seizure was observed after 30000 times of pipe expansion. The liners 171 did not need to be replaced even after 30000 times of pipe expansion (No. 2 in Table 1).

[0059] When the hardness of the jaw 18 was 80 HS (the difference in hardness was 40 HS), significant wear was observed in the liners 171 after 3000 times of pipe expansions, but no seizure was observed at that point. The frequency of replacement of the liners 171 was about every 3000 times of pipe expansion (No. 3 in Table 1).

[0060] Consequently, if seizure occurs, it is only necessary to replace the liners 171. Therefore, the cost of pipe expansion can be reduced. By setting the difference in hardness between the liners 171 and the jaw 18 to 20 to 50 HS, seizure can be reduced. In addition, it turned out that, by changing the difference in hardness between the liners 171 and the jaw 18 within the above range, the amount of wear of the liners can be adjusted, and the frequency of replacement of the liners can be reduced.

[Table 1]

[Table 1]

No	Example	Liners	Jaw	Occurrence of seizure ¹⁾	Occurrence of wear	Replacement of liners
1	Present invention	40 HS	40 HS	Seizure was observed after 1000 times of pipe expansion	No wear was observed after 1000 times of pipe expansion	Liners were replaced after 1000 times of pipe expansion
2	Present invention	40 HS	60 HS	No seizure was observed after 30000 times of pipe expansion	1 mm or less after 3000 times of pipe expansion	Liners did not need to be replaced even after 30000 times of pipe expansion
3	Present invention	40 HS	80 HS	No seizure was observed after 3000 times of pipe expansion	More than 1 mm after 3000 times of pipe expansion	Liners were replaced after 3000 times of pipe expansion
1) As for occurrence of seizure, the surfaces of the liners and the jaw were visually examined.						

EXAMPLE 2

[0061] The appearance, the presence or absence of seizure and the presence or absence of wear, of the sliding surfaces of the liners 171 and the jaw 18 in the case where, as the present invention example, in the expansion of a welded pipe, the material and hardness of the liners 171 and the jaw 18 in Figs. 2 and 3 were as shown in Table 2, was examined. The result is shown in Table 2. Example 2 was conducted to confirm the effects of using copper alloy as liners.

[0062] When the hardness of the liners was 80 HS and the hardness of the jaw 18 was 80 HS (the difference in hardness was 0), no wear was observed in the liners 171 and the jaw 18 and seizure was observed after 1000 times of pipe expansion. The liners 171 were replaced with new ones, and the pipe expansion became smooth (No. 4 in Table 2).

[0063] When liners were made of aluminum bronze (having a hardness of 30 HS) consisting of Cu: 82.3 mass%, Al: 10.4 mass%, Fe: 3.4 mass%, Mn: 1.9 mass%, Ni: 1.82 mass%, the rest: impurity, and the hardness of the jaw 18 was 50 HS (the difference in hardness was 20 HS), slight wear was observed in the liners 171 after 3000 times of pipe expansion. After 90000 times of pipe expansion, the liners 171 were examined. No seizure was observed, and the liners 171 did not need to be replaced (No. 5 in Table 2).

[0064] When liners were made of aluminum bronze (having a hardness of 30 HS) consisting of Cu: 82.3 mass%, Al: 10.4 mass%, Fe: 3.4 mass%, Mn: 1.9 mass%, Ni: 1.82 mass%, the rest: impurity, and the hardness of the jaw 18 was 80 HS (the difference in hardness was 50 HS), significant wear was observed in the liners 171 after 3000 times of pipe expansion, but no seizure was observed even after 10000 times of pipe expansion. The frequency of replacement of the liners 171 was about every 10000 times of pipe expansion (No. 6 in Table 2).

[0065] From the above, it turned out that, by making the liners 171 of aluminum bronze and setting the difference in hardness from the jaw 18 to 20 to 50 HS, seizure can be reduced, and, by appropriately setting the amount of wear, the frequency of replacement of the liners can be made appropriate.

[Table 2]

[Table 2]

No	Example	Liners	Jaw	Occurrence of seizure ¹⁾	Occurrence of wear	Replacement of liners
4	Present invention	Tool steel 80 HS	Tool steel 80 HS	Seizure was observed after 1000 times of pipe expansion	No wear was observed after 1000 times of pipe expansion	Liners were replaced after 1000 times of pipe expansion
5	Present invention	Aluminum bronze 30 HS	Tool steel 50 HS	No seizure was observed after 90000 times of pipe expansion	1 mm or less after 3000 times of pipe expansion	Liners did not need to be replaced even after 90000 times of pipe expansion
6	Present invention	Aluminum bronze 30 HS	Tool steel 80 HS	No seizure was observed after 10000 times of pipe expansion	More than 1 mm after 3000 times of pipe expansion	Liners were replaced after 10000 times of pipe expansion
1) As for occurrence of seizure, the surfaces of the liners and the jaw were visually examined.						

Reference Signs List

[0066]

- 1 steel pipe
- 11 cylinder
- 12 horn
- 13 pipe expansion head
- 14 pipe expander main body
- 15 axial infeed
- 16 cross-feed
- 17 cone
- 170 cone main body
- 1700 segment

1701	groove
171	liner
172	bolt
18	jaw
19	die
20	lubricating oil supply pipe
21	draw bar
22	pipe expansion head outer surface member
100	pipe expanding machine

Claims

1. A pipe expander comprising:

a cone that is fitted around the tip of a draw bar connected to a cylinder and has an outer periphery of which the size changes gradually in an axial direction thereof; and
a pipe expansion head outer surface member disposed on the outer periphery of the cone,
wherein the cone pulled by the cylinder in the axial direction radially expands the pipe expansion head outer surface member to expand a steel pipe placed on the outer periphery of the pipe expansion head outer surface member, and
wherein the cone has a detachable liner on a contact surface thereof with the pipe expansion head outer surface member.

2. The pipe expander according to Claim 1, wherein on the contact surfaces of the liner and the pipe expansion head outer surface member, there is a difference in hardness between the liner and the pipe expansion head outer surface member.

3. The pipe expander according to Claim 2, wherein the difference in hardness is 20 to 50 HS.

4. The pipe expander according to Claim 2 or 3, wherein in the contact surfaces of the liner and the pipe expansion head outer surface member, the hardness of the softer member is 30 HS or more.

5. The pipe expander according to any one of Claims 2 to 4, wherein the softer member is the liner.

6. The pipe expander according to any one of Claims 1 to 5, wherein the liner is made of copper alloy.

FIG. 1

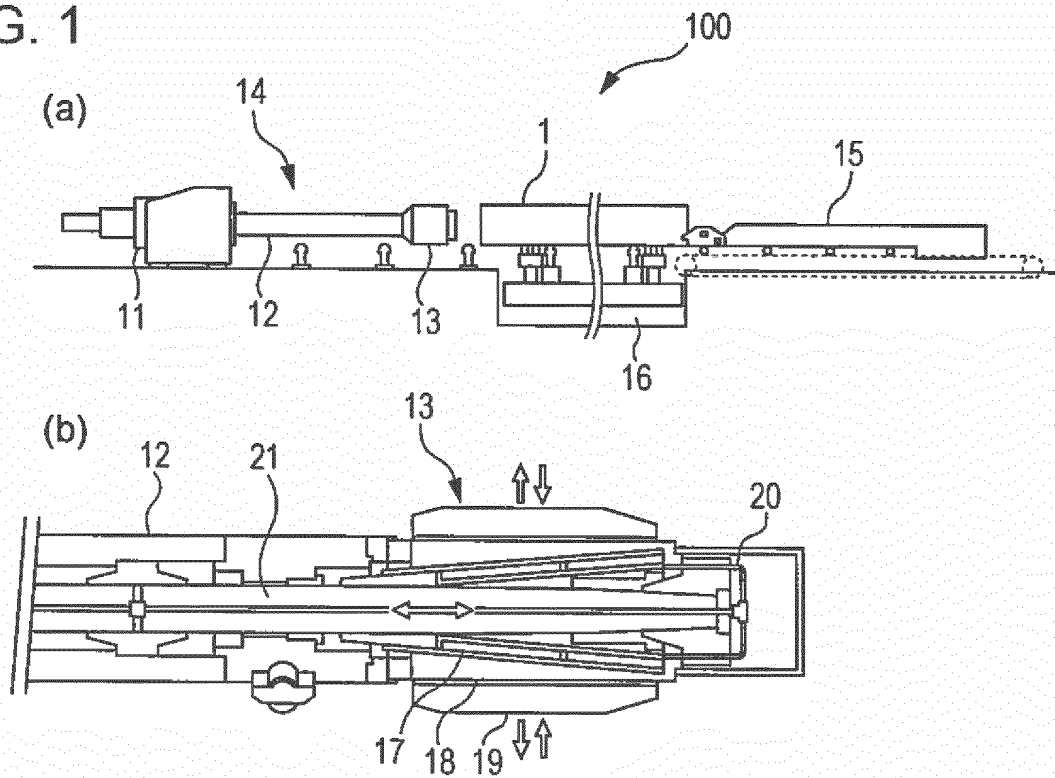


FIG. 2

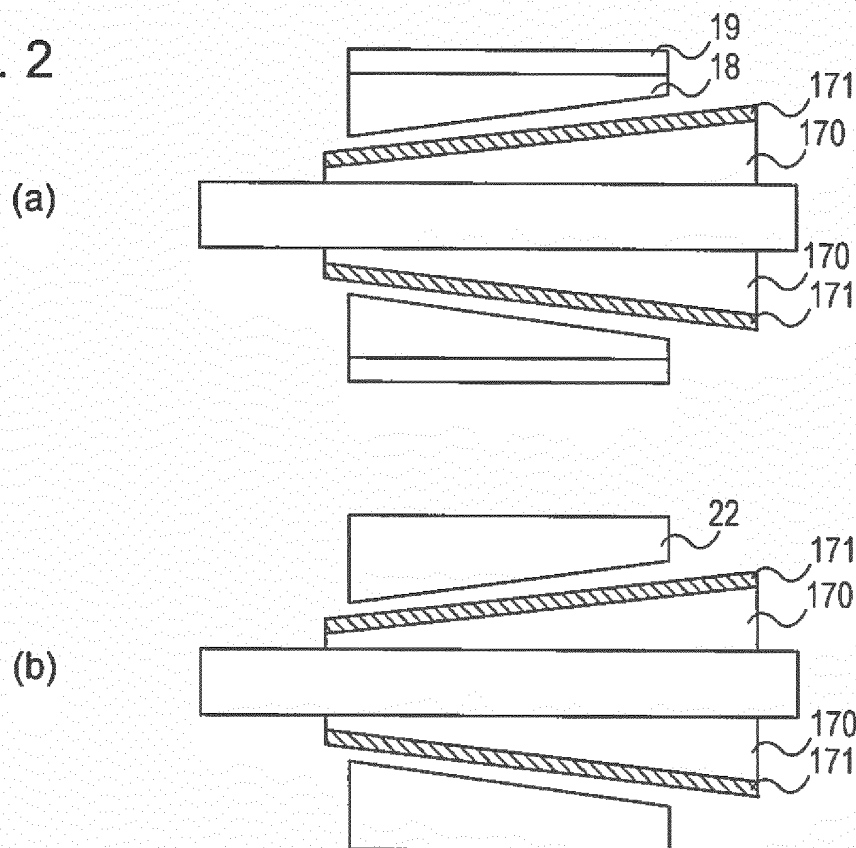


FIG. 3

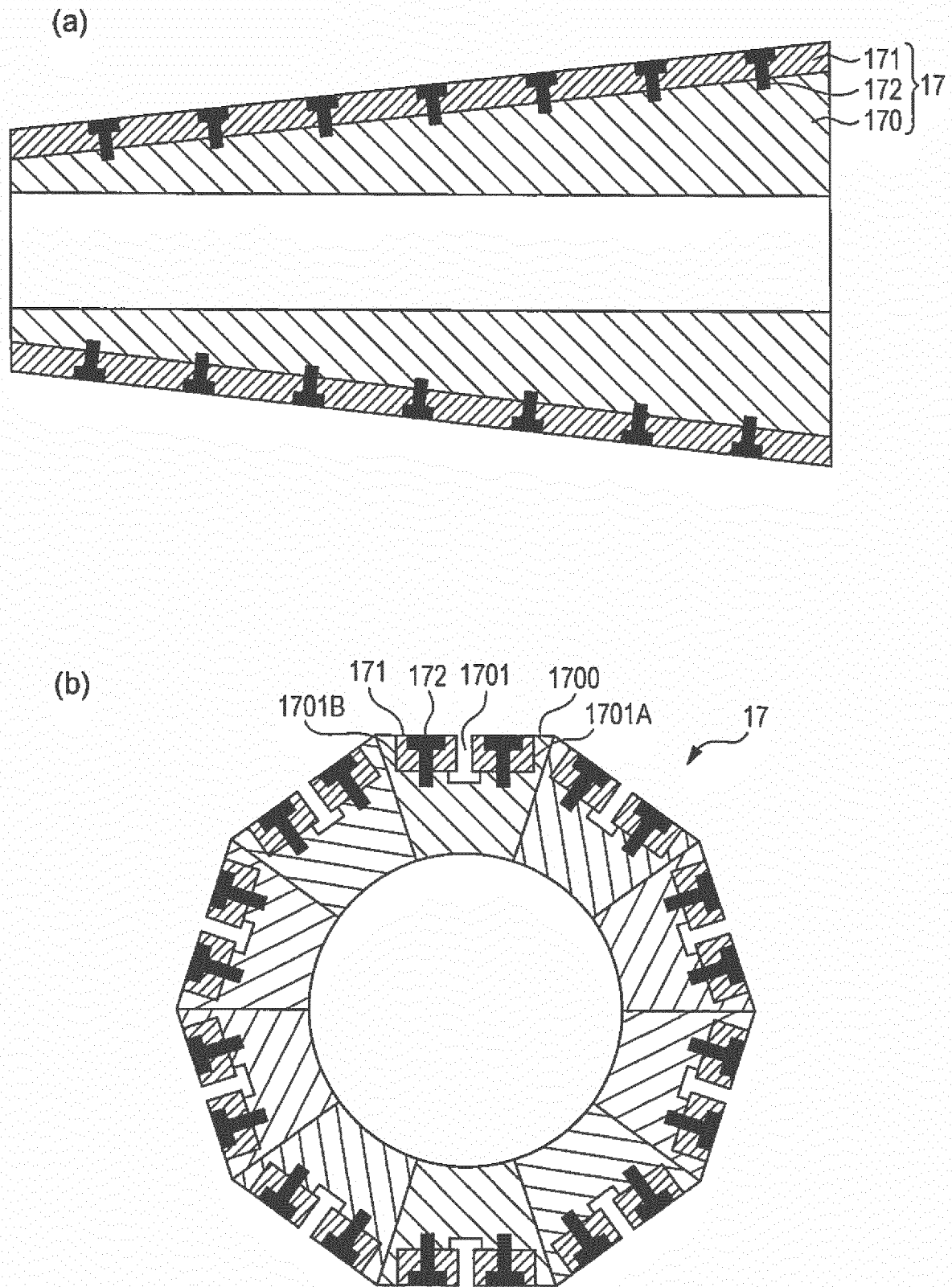
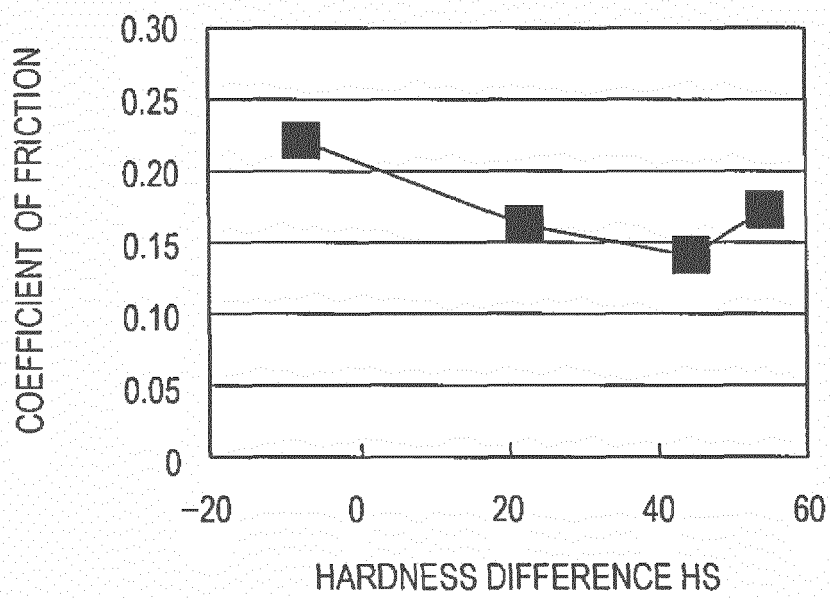


FIG. 4



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/003598

A. CLASSIFICATION OF SUBJECT MATTER

B21D3/14(2006.01)i, B21D39/20(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B21D3/14, B21D39/20

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2015

Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2001-259763 A (SMS Demag AG), 25 September 2001 (25.09.2001), paragraphs [0011] to [0014]; fig. 1 to 2 & US 2001/0020381 A1 & EP 1125654 A2 & DE 10008688 C1	1-2, 5 3-4, 6
Y A	JP 2007-284519 A (JFE Steel Corp.), 01 November 2007 (01.11.2007), fig. 1 (Family: none)	1-2, 5 3-4, 6
A	JP 8-300070 A (Mitsubishi Electric Corp.), 19 November 1996 (19.11.1996), paragraph [0007] (Family: none)	1-6

☒ 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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Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2014-083560 A (JFE Steel Corp.), 12 May 2014 (12.05.2014), paragraphs [0001] to [0040]; fig. 1 to 6 (Family: none)	1-6
A	JP 7-290170 A (Sumitomo Metal Industries, Ltd.), 07 November 1995 (07.11.1995), paragraphs [0001] to [0023]; fig. 1 to 9 (Family: none)	1-6

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 1299723 A [0007]
- JP 5195158 A [0007]
- JP 2007284519 A [0007]

Non-patent literature cited in the description

- Tekko Binran. vol. 3 [0008]