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(54) **STAINLESS STEEL PIPE WITH EXCELLENT CORROSION RESISTANCE AND
MANUFACTURING METHOD THEREOF**

(57) An object of the present invention is to provide a stainless steel pipe which exhibits excellent corrosion resistance so as not to rust at an early stage even in a waterfront environment affected by sea salt particles. The stainless steel pipe has a polishing mark on a surface, an oxide film exhibiting color is not present on the surface, and an average number of surface defects including covering by a metal base of 5 μm or more on the surface is suppressed to 5 or fewer per 0.01 mm^2 .

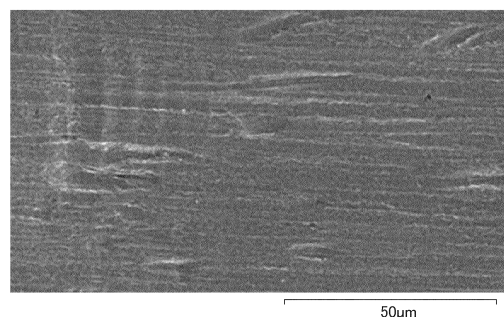


FIG. 1A

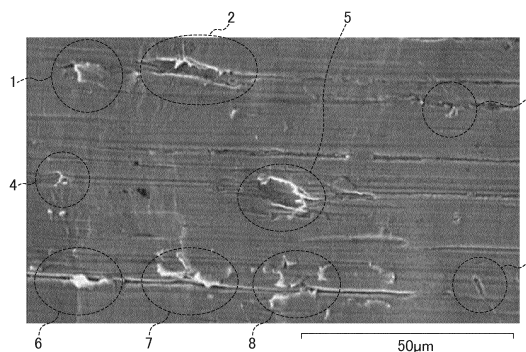


FIG. 1B

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Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to a stainless steel pipe exhibiting excellent corrosion resistance and a method of manufacturing the same.

BACKGROUND ART

10 **[0002]** Stainless steel is widely used in building material applications such as roofing materials, wall materials, and building components since it exhibits excellent weather resistance, processability, weldability, and the like. In addition, a stainless steel pipe is used in applications such as handrails, fences, and pipe shutters after being subjected to surface polishing since it exhibits excellent designing property as well.

15 **[0003]** In the general industrial polishing of this stainless steel pipe, scratch-removing polishing is first conducted in order to remove scratches and the like on the original pipe before being polished and then finish polishing, glossy polishing, and the like are conducted. Dry polishing using a flap wheel, a polishing belt, or the like is conducted in the rough polishing and finish polishing in this polishing operation. Furthermore, there is a case in which wet polishing by buffing is conducted after the above process in order to obtain a desired surface.

20 **[0004]** Conventionally, stainless steel exhibits excellent weather resistance as a material, but there is a case in which the inherent weather resistance of the material is not exerted and remarkable rusting occurs depending on the state of polishing finish, and this is one of the factors to eliminate the stability (reliability) of the weather resistance of stainless steel. For example, there is a case in which rusting occurs in a short period of about one month after stainless steel is constructed into outdoor handrails and the like.

25 **[0005]** It is considered that the oxide film and polishing marks remaining on the surface of the stainless steel pipe after being polished are the starting points of rusting. The remaining oxide film is a film formed due to heat generation at the time of polishing and a Cr-depleted layer is formed right under the oxide film. Hence, rusting proceeds from the oxide film and the Cr-depleted layer right under the oxide film and corrosion resistance is likely to deteriorate when the oxide film remains. In addition, with regard to the polishing marks which are scratches engraved on the surface of the stainless steel pipe by polishing as well, the possibility that it is difficult to remove the oxide film formed by polishing using a flap wheel or the like by buffing and the oxide film remains is higher as the concave portion of the polishing marks is deeper, and rusting proceeds and corrosion resistance is likely to deteriorate since the concave portion of the polishing marks becomes a starting point of rusting.

30 **[0006]** Patent Document 1 proposes a stainless steel pipe capable of maintaining glossiness and weather resistance for a long period by polishing the surface to be in a state in which rusting does not occur in a short period even in an outdoor environment.

35 **[0007]** Patent Document 1: Japanese Unexamined Patent Application, Publication No. 2003-56755

DISCLOSURE OF THE INVENTION

40 Problems to be Solved by the Invention

45 **[0008]** The invention described in Patent Document 1 is a stainless steel pipe having a surface roughness after the final polishing of Ry 0.6 μm or less and an area ratio of the remaining oxide film of 7.0% or less. In other words, it is intended to decrease the oxide films remaining in the concave portions of the polishing marks by setting the surface roughness after final polishing to Ry 0.6 μm or less. In addition, it is intended to suppress progress of rusting starting from the oxide film and the Cr-depleted layer right under the oxide film and deterioration in corrosion resistance by setting the area ratio of the remaining oxide film to 7.0% or less.

50 **[0009]** Here, referring to Examples of Patent Document 1, the area ratio of the remaining oxide film is from 3.1 to 6.8% and the oxide film thus remains in a weather resistance-passed product. Hence, there is still a problem that rusting may proceed from the remaining oxide film and the Cr-depleted layer right under the oxide film and the corrosion resistance may deteriorate.

55 **[0010]** Furthermore, the demand for construction has increased in association with the redevelopment of urban areas and the demand for construction in the waterfront environment has increased in recent years. In the waterfront environment, there is a problem that building components are likely to be affected by sea salt particles which are a kind of aerosol particles contained in the atmosphere and are fine particles composed of salts derived from seawater. Hence, needs for highly corrosion resistant building components have increased.

[0011] In Patent Document 1, SUS304 is mentioned as one steel type of stainless steel pipes exhibiting excellent weather resistance. However, SUS304 has a problem that it rusts at an early stage and requires maintenance in a

waterfront environment affected by sea salt particles.

[0012] The present invention has been made to solve the problem described above and an object thereof is to provide a stainless steel pipe which exhibits excellent corrosion resistance so as not to rust at an early stage even in a waterfront environment affected by sea salt particles and a method of manufacturing the same.

Means for Solving the Problems

[0013] The present inventors have carried out investigations on the stainless steel pipe described in Patent Document 1. In Examples of Patent Document 1, dry polishing using a flap wheel is conducted. The oxide film on the surface of the stainless steel pipe of Examples of Patent Document 1 using this polishing method remains at an area ratio of 3.1% or more. As a result of investigations on the factors of this, it has been found out that the temperature of the surface of the stainless steel pipe increases high and an oxide film is formed at the time of polishing using a flap wheel, which is a dry polishing and surface defects are caused together with polishing marks which are scratches engraved by high polishing resistance by dry polishing. The term "surface defect" as referred to herein is a defect having a form in which the metal on the surface partly peels off and covers the base portion as the polishing material and polishing paper are continuously brought into contact with the surface of the steel pipe and polished when polishing the surface of the steel pipe, and it is referred to as "burr" or "covering". A surface defect includes portions at which the metal is turned up as a strip shape or a bamboo leaf shape, and it is a defect having a maximum length from one end portion of the portion bonded to the base to the other end portion at the peeling tip of 5 μm or more. The surface defect forms a microgap with the surface base portion of the stainless steel pipe, and thus crevice corrosion is likely to occur and a decrease in corrosion resistance of the steel pipe is caused.

[0014] The present inventors have found out a stainless steel pipe exhibiting excellent corrosion resistance and a method of manufacturing the same based on the analysis results.

[0015] In other words, the present invention provides a stainless steel pipe exhibiting excellent corrosion resistance and a method of manufacturing the same of the following (1) to (3) .

(1) A stainless steel pipe exhibiting excellent corrosion resistance, in which the stainless steel pipe has a polishing mark on a surface, an oxide film exhibiting color is not present on the surface, and an average number of surface defects including covering by a metal base of 5 μm or more on the surface is suppressed to 5 or fewer per 0.01 mm^2 . The stainless steel pipe of the present invention exhibits excellent design property and antiglare property since it has polishing marks on the surface thereof. In addition, rusting starting from the oxide film and the Cr-depleted layer right under the oxide film hardly proceeds and the corrosion resistance hardly deteriorates since the oxide film exhibiting color is not present on the surface of the stainless steel pipe. Furthermore, crevice corrosion is suppressed and a stainless steel pipe exhibiting excellent corrosion resistance is obtained since the average number of surface defects including covering by the metal base of 5 μm or more on the surface of the stainless steel pipe is suppressed to 5 or fewer per 0.01 mm^2 .

(2) A method of manufacturing the stainless steel pipe of (1), the method including a polishing step of polishing a surface of a stainless steel pipe with a solid polishing agent.

(3) The manufacturing method of (2), in which the surface of the stainless steel pipe is polished by attaching the solid polishing agent to a polishing flap wheel in the polishing step.

Effects of the Invention

[0016] According to the present invention, it is possible to provide a stainless steel pipe which exhibits excellent corrosion resistance so as not to rust at an early stage even in a waterfront environment affected by sea salt particles and a method of manufacturing the same.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

Fig. 1 is a photograph of the surface enlarged using an optical microscope of a stainless steel pipe, Fig. 1(a) is a surface on which the generation of surface defects is suppressed, and Fig. 1(b) is a surface having surface defects. Fig. 2 is a view illustrating the relationship between surface defects and a change in current density, Fig. 2(a) is an enlarged photograph illustrating surface defects of a stainless steel pipe, and Fig. 2(b) is a graph illustrating a change in current density in pitting potential measurement.

Fig. 3 is a view illustrating the relationship between surface defects and a change in current density, Fig. 3(a) is an enlarged photograph illustrating the surface of a stainless steel pipe on which the generation of surface defects is

suppressed, and Fig. 3(b) is a graph illustrating a change in current density in pitting potential measurement.

Fig. 4 is a photograph of the surface enlarged using an optical microscope of the stainless steel pipe of Comparative Example 2.

Fig. 5 is a photograph of the surface enlarged using an optical microscope of the stainless steel pipe of Reference Example 1.

Fig. 6 is a photograph of the surface of a stainless steel pipe after a CCT test, Fig. 6(a) illustrates the surface of Example 1, and Fig. 6(b) illustrates the surface of Comparative Example 1.

PREFERRED MODE FOR CARRYING OUT THE INVENTION

[0018] Hereinafter, embodiments for carrying out the present invention will be described. It should be noted that the present invention is not to be interpreted restrictively by the embodiments.

(Stainless Steel Pipe)

[0019] The stainless steel pipe of the present invention is a stainless steel pipe exhibiting excellent corrosion resistance since it has a polishing mark on the surface, an oxide film exhibiting color is not present on the surface, and an average number of surface defects including covering by the metal base of 5 μm or more on the surface is suppressed to 5 or fewer per 0.01 mm^2 .

[0020] In the present invention, the surface of the stainless steel pipe is subjected to polishing finish so as to impart unevenness and gloss to the surface. By this, the stainless steel pipe becomes a stainless steel pipe which have polishing marks and exhibits excellent design property and antiglare property. The polishing marks are scratches engraved on the surface of the stainless steel pipe by polishing.

[0021] With regard to the polishing marks on the surface after polishing, the possibility that the oxide film formed by polishing using a flap wheel or the like remains is higher as the concave portion of the polishing marks is deeper, and rusting proceeds and corrosion resistance is likely to deteriorate since the concave portion of the polishing marks becomes a starting point of rusting. Accordingly, the surface roughness Ra of the surface of the stainless steel pipe in the present invention after polishing is preferably from 0.1 to 1.0 μm and more preferably from 0.2 to 0.5 μm . The surface roughness after polishing is measured in conformity to JIS B0601, and it can be measured using a contact type surface roughness tester, for example.

[0022] As polishing finish, dry polishing using a flap wheel or the like has been conventionally conducted, but the temperature of the surface of the stainless steel pipe increases high and an oxide film is formed when dry polishing is conducted. Meanwhile, the stainless steel pipe of the present invention is characterized in that an oxide film exhibiting color is not present on the surface. The present inventors believe that the reason for this is because the oxide film on the surface is removed as the stainless steel pipe of the present invention is polished with a solid polishing agent. In addition, the formation of oxide film is further suppressed as the solid polishing agent is attached to the polishing flap wheel.

[0023] In the present invention, the fact that an oxide film exhibiting color is present refers to a case in which an oxide film which is a spot-like substance exhibiting color is present at an area ratio of 5% or more in 50 μm square when arbitrary 10 points on the surface of the stainless steel pipe are observed at a magnification of 400-fold using an optical microscope. Here, the color is not limited to a specific one, and it may be a color which can be visually distinguished from the metal base or metallic luster of the stainless steel pipe. A typical color as the color is dark reddish-brown.

[0024] In addition, when dry polishing using a flap wheel or the like is conducted as polishing finish, the polishing material and the polishing paper are continuously brought into contact with the surface of the stainless steel pipe and a surface defect which is burr or covering that the metal constituting the surface partly peels off and covers the base portion is caused. The surface defect is a factor of crevice corrosion since it forms a microgap with the surface base portion of the stainless steel pipe.

[0025] Fig. 1 is a photograph of the surface enlarged using an optical microscope of the stainless steel pipe, Fig. 1(a) is a surface on which the generation of surface defects is suppressed, and Fig. 1(b) is a surface having surface defects. Fig. 1(a) is the surface of the stainless steel pipe of the present invention, which has polishing marks but on which the generation of surface defects is suppressed. Meanwhile, Fig. 1(b) is a dry polished surface of a stainless steel pipe, and surrounded portions 1 to 9 represent surface defects that the metal constituting the surface partly peels off and covers the base portion. The present inventors have analyzed the reason why the generation of surface defects is suppressed on the surface of the stainless steel pipe of the present invention after polishing as illustrated in Fig. 1(a) is because a solid polishing agent is used at the time of polishing. In addition, the generation of surface defects is further suppressed by attaching the solid polishing agent to the polishing flap wheel. Incidentally, the white horizontal line in Fig. 1 represents a convex portion formed during polishing, and the concave portion between the white horizontal line which is a convex portion and the white horizontal line adjacent thereto is a polishing mark.

[0026] In the present invention, the surface defects refer to those having covering by the metal base in which the

maximum length portion of the defect has a size of 5 μm or more. In addition, the surface is defined to be in a state in which the generation of surface defects is suppressed in the present invention in a case in which the average number of measured surface defects is 5 or fewer when a range of 100 $\mu\text{m} \times 100 \mu\text{m}$ (0.01 mm^2) at arbitrary 10 points on the polished surface of a stainless steel pipe is enlarged by 200-fold and observed using an optical microscope. The number of surface defects on the polished surface of the stainless steel pipe is more preferably 3 or fewer and still more preferably 2 or fewer per unit area of 100 $\mu\text{m} \times 100 \mu\text{m}$ (0.01 mm^2). Incidentally, there is no upper limit to the maximum length portion of surface defects, but the upper limit may be set to 50 μm as a reference value in the measurement.

[0027] Fig. 2 and Fig. 3 are views illustrating the relationship between surface defects and a change in current density, Fig. 2(a) is an enlarged photograph illustrating surface defects of a stainless steel pipe, Fig. 3(a) is an enlarged photograph illustrating the surface of a stainless steel pipe on which the generation of surface defects is suppressed, and Fig. 2(b) and Fig. 3(b) are graphs illustrating a change in current density in pitting potential measurement of the stainless steel pipes of Fig. 2(a) and Fig. 3(a), respectively.

[0028] The pitting potential measurement method of stainless steel conforms to JIS G0577, and the method B is used. The method B is a pitting potential measurement method by a potentiodynamic method in a 3.5mass% sodium chloride aqueous solution. The pH of the sodium chloride aqueous solution is set to 7 and the temperature is set to 30°C. In addition, the potential sweep rate is set to 20 mV/min.

[0029] As illustrated in Figs. 3(a) and 3(b), in the case of a stainless steel pipe having a surface on which the generation of surface defects is suppressed, a change in the value of the current density at a potential lower than the pitting potential is small and the portion at which the rate of change (maximum current density / minimum current density) in the current density in a range of from the natural potential to the pitting potential, namely, a potential range of from 0.1 to 0.5 (part B in Fig. 3(b)) is 10 or more is not recognized in the change in current density in the pitting potential measurement.

[0030] Meanwhile, as illustrated in Figs. 2(a) and 2(b), in the case of a stainless steel pipe having surface defects, the change in the value of the current density at a potential lower than the pitting potential is great and the portion at which the rate of change in the current density in a range of from the natural potential to the pitting potential, namely, a potential range of from 0.1 to 0.3 V (part A in Fig. 2(b)) exceeds 10 is at ten or more potential positions in the change in current density in the pitting potential measurement. This great change in current density is caused by occurrence of corrosion. Therefore, the present inventors presume that a great change in current density indicates the occurrence of crevice corrosion caused by the presence of surface defects. Accordingly, in the present invention, the portion at which the rate of change (maximum current density / minimum current density) in the current density in a range of from the natural potential to the pitting potential is 10 or more is preferably at fewer than ten potential positions and more preferably at five or fewer places in the change in current density in pitting potential measurement.

[0031] As a composition in the case of using ferritic stainless steel as the material for the stainless steel pipe of the present invention, for example, C is contained preferably at 0.02% by mass or less since it tends to decrease corrosion resistance when being contained in a great amount although it is an element useful for obtaining the strength of steel. Si is contained preferably at 1.00% by mass or less since it tends to harden the steel when being contained in a great amount although it is an element useful as a deoxidizer and a heat source in the steelmaking process. Mn is contained preferably at 2.00% by mass or less, and more preferably at 1.00% by mass or less since it tends to form an austenite phase when being contained in a great amount although it is an element useful as deoxidation in the steelmaking process. Cr is contained preferably at from 17.00% to 30.00% by mass and more preferably at from 20.00% to 24.00% by mass since it tends to not only increase the cost but also decrease the processability when being contained in a great amount although it is an element useful for securing corrosion resistance. Mo is contained preferably at from 1.00% to 2.50% by mass and more preferably at from 1.00% to 1.50% by mass since it tends to not only increase the cost but also decrease the processability when being contained in a great amount although it is an element useful for improving the corrosion resistance of stainless steel in the presence of Cr. It is more preferable as P is contained in a smaller amount since it decreases corrosion resistance, and P is contained preferably at 0.040% by mass or less. It is more preferable as S is contained in a smaller amount since it decreases corrosion resistance, and S is contained preferably at 0.030% by mass or less. Ni is contained preferably at 0.6% by mass or less since it causes the formation of an austenite phase and high cost when being contained too much although it is preferred from the viewpoint of an effect of suppressing the progress of corrosion and of being effective in improvement of toughness of ferritic stainless steel pipes. With regard to Ti and Nb, it is preferable to contain one kind or two kinds of these. Ti is contained preferably at from 0.05% to 0.5% by mass since a large amount of Ti content tends to decrease the surface quality of steel although it is preferred from the viewpoint of having a strong affinity for C and N and suppressing intergranular corrosion of ferritic stainless steel pipes. Nb is contained preferably at from 0.1% to 0.6% by mass since a large amount of Nb content tends to hinder toughness although it is preferred from the viewpoint of having a strong affinity for C and N and suppressing intergranular corrosion of ferritic stainless steel pipes. N is contained preferably at 0.025% by mass or less since it, like C, tends to decrease corrosion resistance when being contained in a great amount. Al is contained preferably at from 0.01% to 0.50% by mass since it decreases the weldability and low temperature toughness of steel as well as deteriorates the surface quality when being excessively added although it is an element effective in refining and casting as a deoxidizer. The

balance is preferably Fe and inevitable impurities. In addition, for example, it is also possible to use one containing C at 0.02% by mass or less, Si at 0.40% by mass or less, Mn at 0.40% by mass or less, Cr at from 21.00% to 23.00% by mass, Mo at from 1.00% to 1.50% by mass, P at 0.040% by mass or less, S at 0.030% by mass or less, Ni at 0.60% by mass or less, Ti at from 0.05% to 0.5% by mass, Nb at from 0.10% to 0.6% by mass, N at 0.025% by mass or less, Al at 0.15% by mass or less, and Fe as the balance as the stainless steel pipe of the present invention.

[0032] As the material for the stainless steel pipe of the present invention, a material having a pitting (corrosion) index (PI) of 20 or more is preferable. PI is determined by the following Equation (1). $PI = Cr + 3Mo$ ---Equation (1)

[0033] The stainless steel pipe of the present invention having a pitting index (PI) of 20 or more exhibits excellent corrosion resistance. Hence, rusting of the stainless steel pipe of the present invention can be suppressed whereas SUS304 having a low pitting index of 19 rusts at an early stage in a waterfront environment affected by sea salt particles. The pitting index (PI) is more preferably 24 or more and still more preferably 30 or more from the viewpoint of corrosion resistance.

(Manufacturing Method)

[0034] The method of manufacturing a stainless steel pipe of the present invention is a manufacturing method including a polishing step of polishing the surface of a stainless steel pipe with a solid polishing agent.

[0035] The solid polishing agent is not particularly limited and can be used as long as it contains a fatty acid and mineral fat and oil.

[0036] It is preferable that the solid polishing agent contains oxides such as SiO_2 , Al_2O_3 , and CrO_2 . The content of oxides such as SiO_2 , Al_2O_3 , and CrO_2 is preferably from 50% to 80% by mass, more preferably from 55% to 75% by mass, and particularly preferably from 60% to 70% by mass.

[0037] As the fatty acid, it is preferable to use stearic acid, myristic acid, and the like. As the mineral fat and oil, it is preferable to use palmitic acid and the like.

[0038] In the present method of manufacturing a stainless steel pipe, it is preferable to polish the surface of the stainless steel pipe using a polishing flap wheel to which the solid polishing agent is attached in the polishing step.

[0039] As described above, when dry polishing using a flap wheel or the like is conducted as polishing finish, the polishing material and the polishing paper are continuously brought into contact with the surface of the stainless steel pipe and a surface defect which is burr or covering that the metal constituting the surface partly peels off and covers the base portion is caused. Meanwhile, it is preferable to conduct wet polishing by attaching the solid polishing agent to the polishing flap wheel in the method of manufacturing a stainless steel pipe of the present invention. This makes it possible to decrease the polishing resistance even in a case in which the polishing material and the polishing paper are continuously brought into contact with the surface of the stainless steel pipe, and the generation of a surface defect which is burr or covering that the metal constituting the surface partly peels off and covers the base portion is likely to be further suppressed.

[0040] Incidentally, the present invention is not limited by the above embodiment. For example, buffing using a solid polishing agent may be conducted after wet polishing is conducted by attaching a solid polishing agent to a polishing flap wheel. In addition, it is possible to manufacture a stainless steel pipe which has random polishing marks on the surface of the stainless steel pipe and on which generation of an oxide film exhibiting color and surface defects is suppressed by manually conducting polishing by the movement formed by combining an eccentric motion and a rotational motion using a polishing apparatus (air sander) to which a nonwoven fabric is attached after a solid polishing agent is applied and wet polishing is conducted as well.

EXAMPLES

[0041] Piping and shape modification of a stainless steel pipe were conducted, and polishing finish for decoration was conducted. The following two types of stainless steel pipes were used. The composition (mass%) and dimensions are as follows.

Steel Type 1 (SUS445J1) Cr: 22%, Mo: 1.05%, Ti: 0.2%, Nb: 0.2%, Al: 0.09%, and Fe: balance
Steel Type 2 (SUS304) Cr: 18%, Ni: 8%, Si: 0.6%, Mn: 0.8%, and Fe: balance

[0042] Dimensions: 34 mm in diameter $\times$ 1.5 mm in thickness $\times$ 4000 mm in length.

[0043] Polishing was conducted in Lines 1 to 4 as follows. In addition, the polishing conditions are as follows.

[0044] Line 1 is a line in which five flap wheels (#240, #240, #240, #400, and #600) are arranged so as to polish the surface of steel pipe in the circumferential direction (to impart polishing marks in the circumferential direction). Line 2 is a line in which four flap wheels (#240, #240, #240, and #400) are arranged so as to polish the surface of steel pipe in the longitudinal direction (to impart polishing marks in the longitudinal direction). Line 3 is a line in which four flap wheels

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(#150, #150, #150, and #320) are arranged so as to polish the surface of steel pipe in the longitudinal direction (to impart polishing marks in the longitudinal direction). Line 4 is a line composed of three flap wheels (#320, #400, and #600) arranged so as to polish the surface of steel pipe in the longitudinal direction (to impart polishing marks in the longitudinal direction) and two cotton buffs (#400 and #400) arranged so as to polish the surface of steel pipe in the circumferential direction (to impart polishing marks in the circumferential direction). Here, a solid polishing agent was applied to the flap wheel in Line 1 and Line 4. Meanwhile, a solid polishing agent was not applied in Line 2 and Line 3. Incidentally, "#240" and the like represent the mesh grading.

(Polishing Conditions)

[0045]

Line speed: 1.8 m/min

Number of rotations of pipe: 380 rpm

Number of rotations of wheel: 1500 rpm

Wheel diameter: 400 mm

(Solid Polishing Agent)

[0046] The solid polishing agent had a SiO_2 content of 75% by mass, a content of stearic acid which was a fatty acid of 16% by mass, and a content of palmitic acid which was a mineral fat and oil of 3.8% by mass.

(Example 1)

[0047] Polishing of Steel Type 1 was conducted in Line 1 (applied with a solid polishing agent).

(Example 2)

[0048] Polishing of Steel Type 1 was conducted in Line 3 (not applied with a solid polishing agent) and then in Line 4 (applied with a solid polishing agent). Thereafter, polishing to uniformly adjust the random polishing marks was manually conducted by the movement formed by combining an eccentric motion and a rotational motion using a polishing apparatus (air sander) to which a nonwoven fabric (#80) was attached without applying a solid polishing agent.

(Comparative Example 1)

[0049] Polishing of Steel Type 1 was conducted in Line 2 (not applied with a solid polishing agent).

(Comparative Example 2)

[0050] Polishing of Steel Type 2 was conducted in Line 2 (not applied with a solid polishing agent).

(Reference Example 1)

[0051] Polishing of Steel Type 2 was conducted in Line 1 (applied with a solid polishing agent).

(Surface Defects)

[0052] The polished surface of a stainless steel pipe was enlarged by 200-fold and observed in a range of $100\text{ }\mu\text{m} \times 100\text{ }\mu\text{m}$ (0.01 mm^2) using an optical microscope. The surface was evaluated as "○" to be in a state in which the generation of surface defects was suppressed in a case in which the number of surface defects having covering by the metal base of $5\text{ }\mu\text{m}$ or more was 5 or fewer, and the surface was evaluated as "×" to be in a state in which the generation of surface defects was suppressed in a case in which the number of surface defects was more than 5 (see Table 1).

[0053] As presented in Table 1, the surface of the stainless steel pipe of Example 1 did not have surface defects as illustrated in Fig. 1(a). Meanwhile, the surface of the stainless steel pipe of Comparative Example 1 had at least nine surface defects as illustrated in Fig. 1(b), and thus it was not in a state in which the generation of surface defects was suppressed. In addition, the surface of the stainless steel pipe of Comparative Example 2 had at least 6 surface defects as illustrated in Fig. 4, and thus it was not in a state in which the generation of surface defects was suppressed. Incidentally, in Reference Example 1, there was no surface defect as illustrated in Fig. 5.

(Oxide Film)

[0054] The surface of the stainless steel pipe was observed at a magnification of 400-fold using an optical microscope, and to what extent an oxide film which was a spot-like substance exhibiting dark reddish-brown was present in 50 μm square as an area ratio was calculated. The surface was evaluated as "O(Good)" not to have an oxide film exhibiting color in a case in which the area ratio of the remaining oxide film was 3% or more and less than 5%, the surface was evaluated as "○ (Excellent)" in the case of a more preferred state in which the area ratio of the remaining oxide film was less than 3%, and the surface was evaluated as "× (Failure)" to have an oxide film exhibiting color in a case in which the area ratio was 5% or more (see Table 1).

[0055] As presented in Table 1, the area ratio of the oxide film was 1% or less in Example 1, the area ratio of the oxide film was 3% in Example 2, and an oxide film exhibiting color was not thus present on the surface of the stainless steel pipes. Meanwhile, the area ratio of the oxide film was 15% and 20% in Comparative Examples 1 and 2, respectively and an oxide film exhibiting color was thus present on the surface of the stainless steel pipes. Incidentally, the area ratio of the oxide film was 2% and an oxide film exhibiting color was not thus present on the surface of the stainless steel pipe in Reference Example 1.

(Corrosion Resistance Test)

[0056] The stainless steel pipes of Examples 1 and 2, Comparative Examples 1 and 2, and Reference Example 1 were subjected to a corrosion resistance test (salt-dry-wet combined cyclic corrosion test (CCT test)) under the following conditions. Conditions: (1) Salt water spray (35°C, 5%NaCl, 15 minutes)

(2) Drying (60°C, 30%RH, 60 minutes)

(3) Wetting (50°C, 95%RH, 3 hours)

[0057] The above conditions (1) to (3) constituted one cycle, and the cycle was repeatedly conducted by 30 cycles. Evaluation: the stainless steel pipe was evaluated as "○(Good)" to exhibit good corrosion resistance when the rusting area after the test was within 5% of the entire surface of the steel pipe, as "△ (Passing)" when the rusting area was more than 5% and 15% or less, and as "×(Failure)" to exhibit poor corrosion resistance when the rusting area was more than 15% (see Table 1).

[0058] The surface photographs after the CCT test of Example 1 and Comparative Example 1 are illustrated in Fig. 6. In Example 1, it has been indicated that rusting has not occurred on the surface even after the CCT test as illustrated in Fig. 6(a) and the corrosion resistance is excellent. Meanwhile, in Comparative Example 1, rusting has occurred on the surface after the CCT test as illustrated in Fig. 6(b) and the corrosion resistance is inferior. Incidentally, in Reference Example 1, the corrosion resistance is △ since the corrosion resistant level of the base material itself is low. The corrosion resistant level of the base material in a waterfront environment affected by sea salt particles is preferably 24 or more as a pitting index (PI).

[Table 1]

	Surface defects	Oxide film	Corrosion resistance
Example1	○	○	○
Example2	○	○	○
Comparative Example1	×	×	×
Comparative Example2	×	×	×
Reference Example1	○	○	△

EXPLANATION OF REFERENCE NUMERALS

[0059]

1 to 9 ... Surface defect

A and B ... Region having change in current density

Claims

1. A stainless steel pipe exhibiting excellent corrosion resistance, wherein
the stainless steel pipe has a polishing mark on a surface,
an oxide film exhibiting color is not present on the surface, and
an average number of surface defects including covering by a metal base of 5 μm or more on the surface is
suppressed to 5 or fewer per 0.01 mm^2 .
2. A method of manufacturing the stainless steel pipe according to claim 1, the method comprising a polishing step of
polishing a surface of a stainless steel pipe with a solid polishing agent.
3. The manufacturing method according to claim 2, wherein the surface of the stainless steel pipe is polished by
attaching the solid polishing agent to a polishing flap wheel in the polishing step.

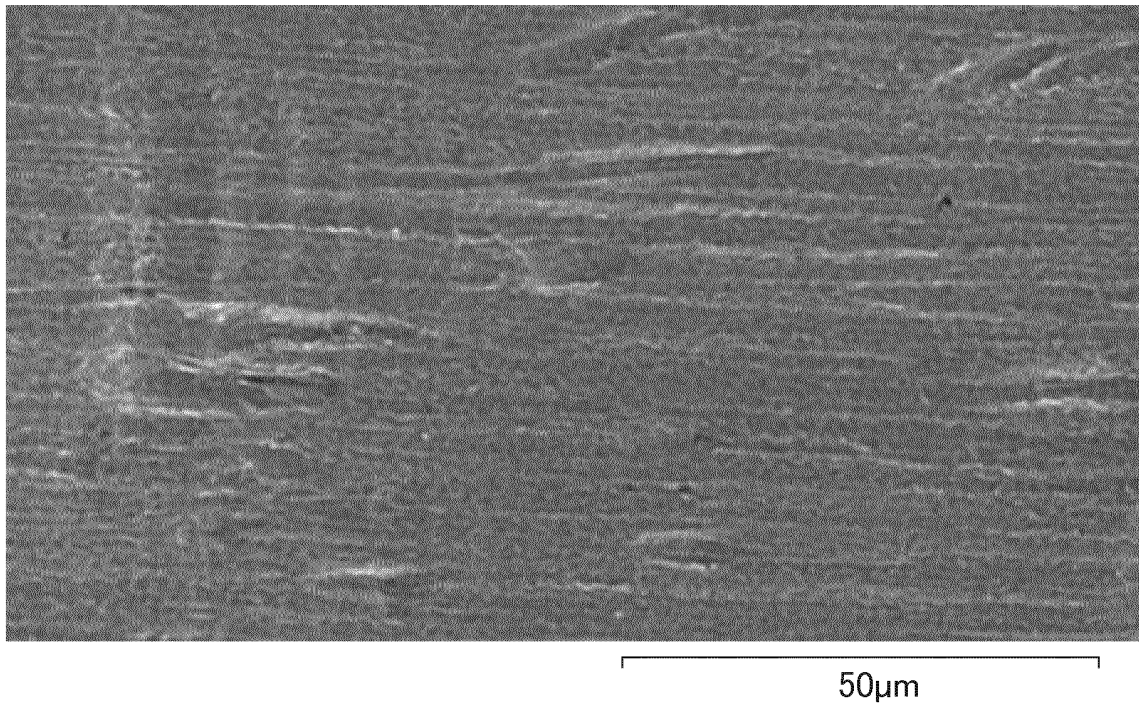


FIG. 1A

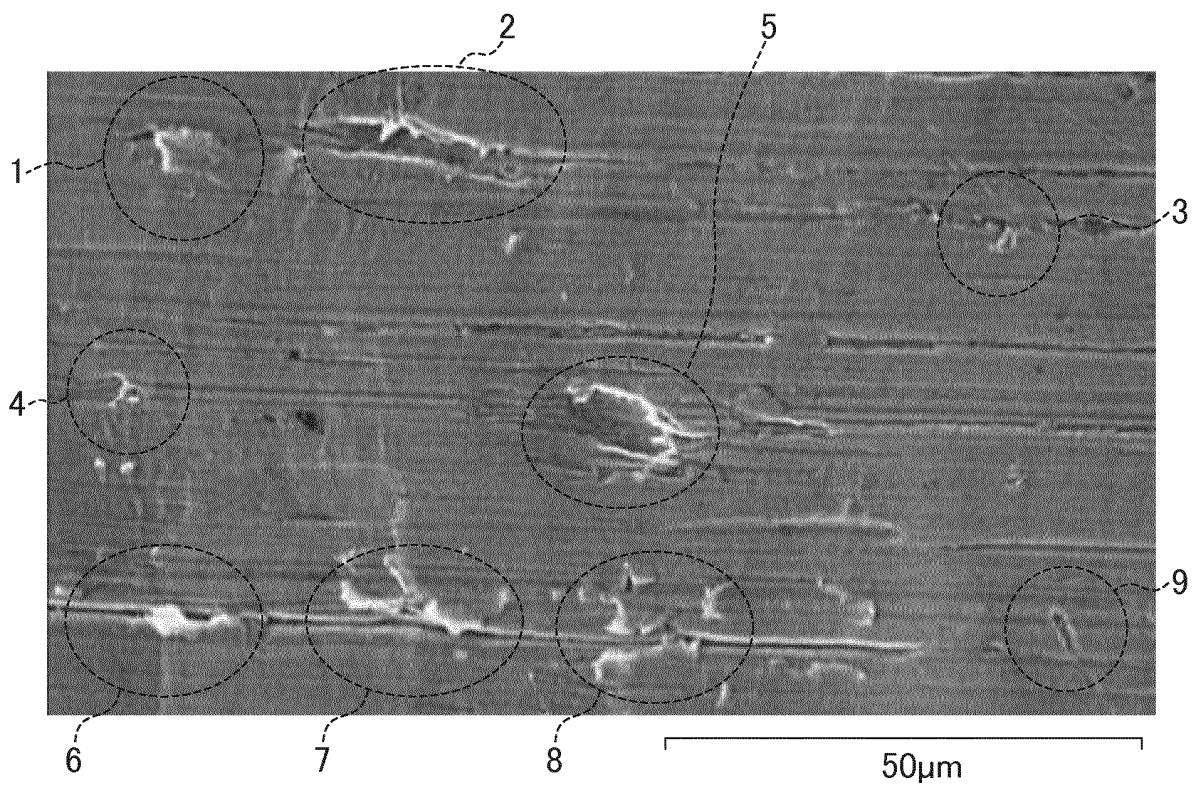


FIG. 1B

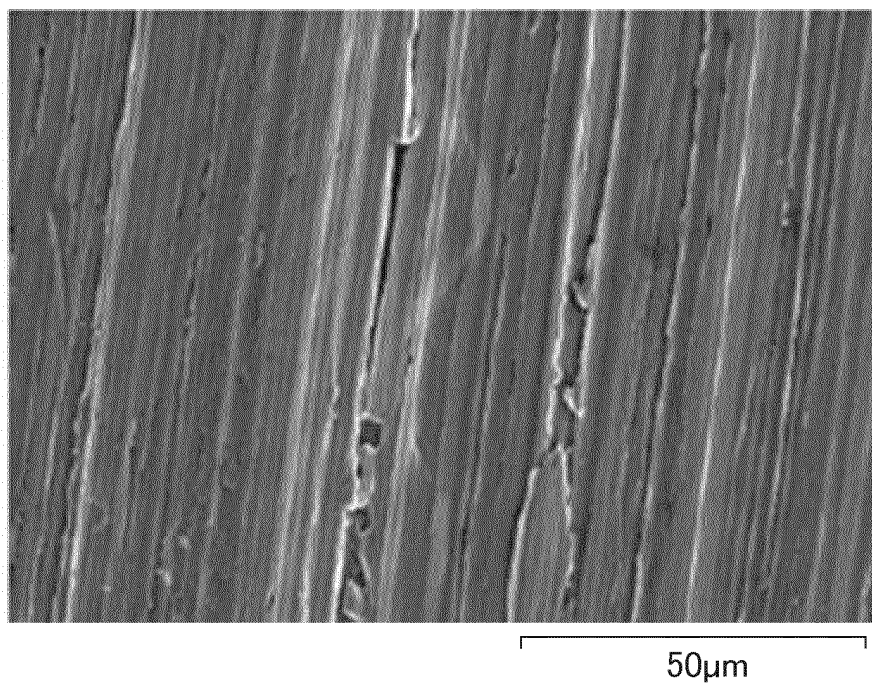


FIG. 2A

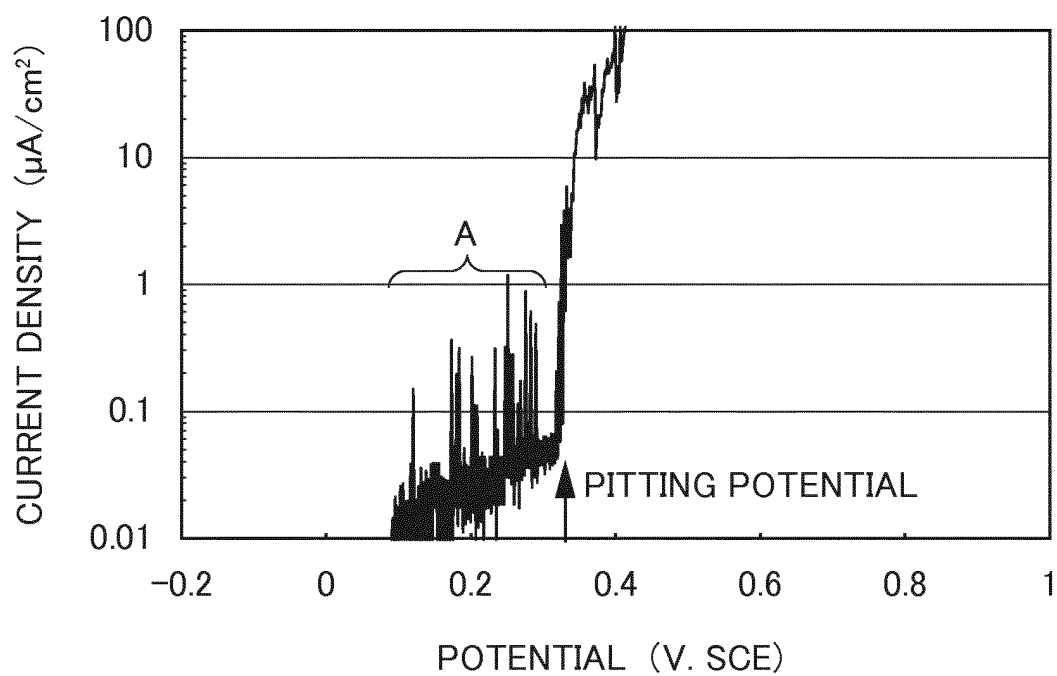


FIG. 2B

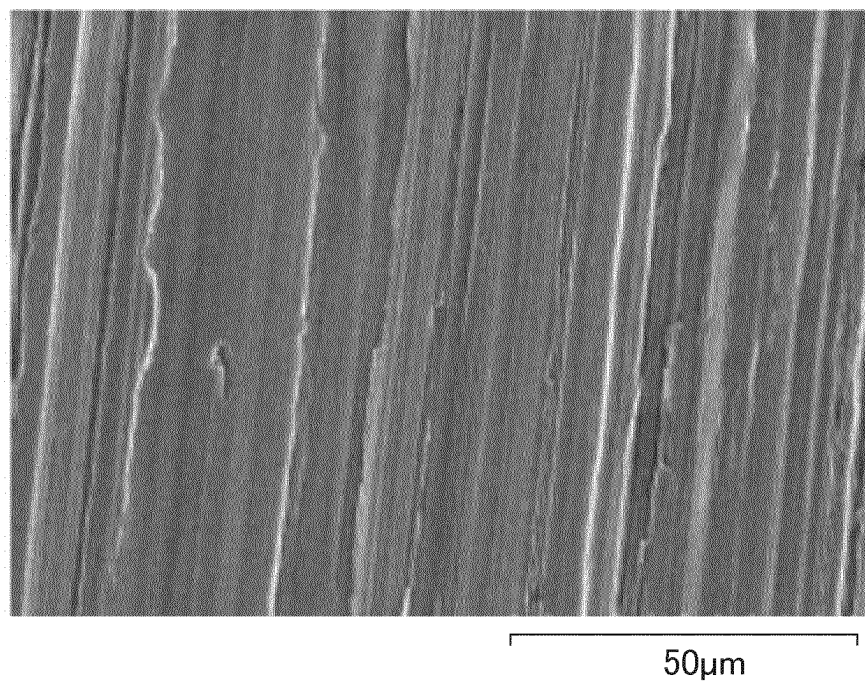


FIG. 3A

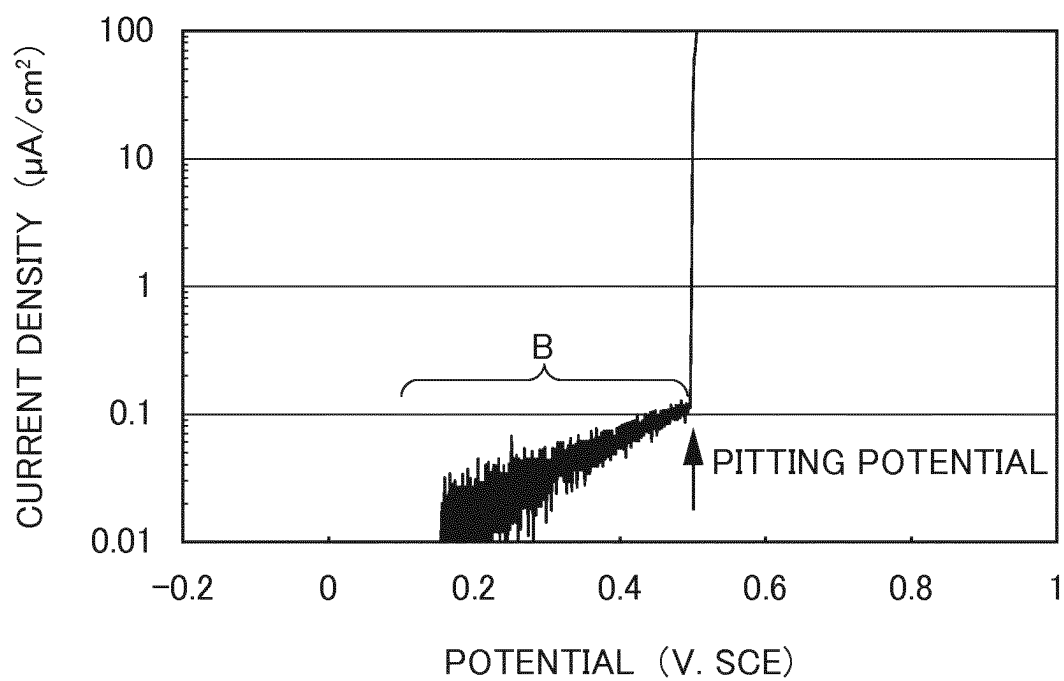


FIG. 3B

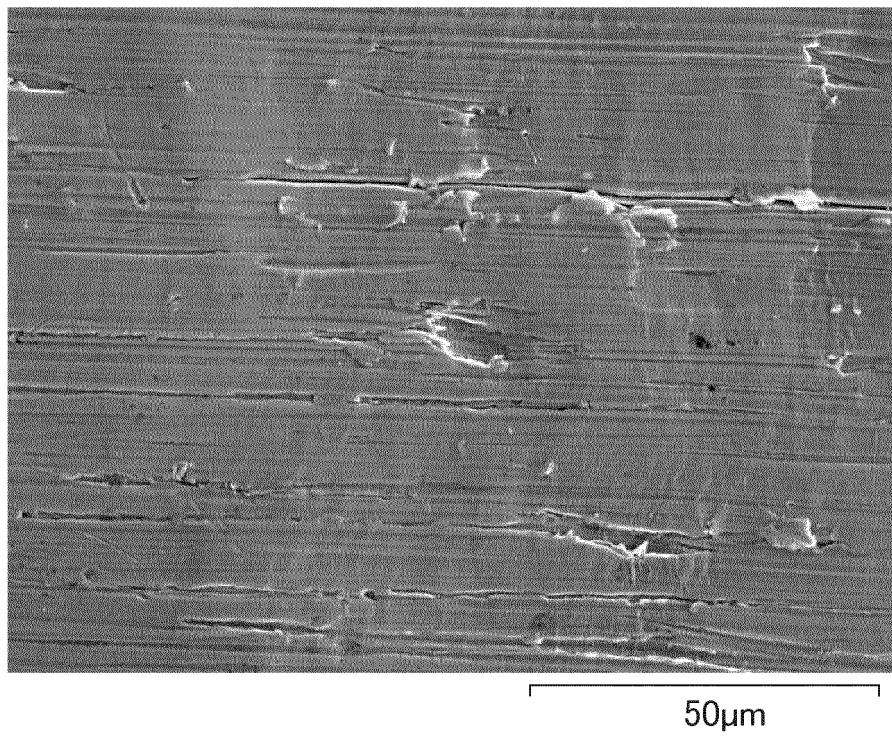


FIG. 4

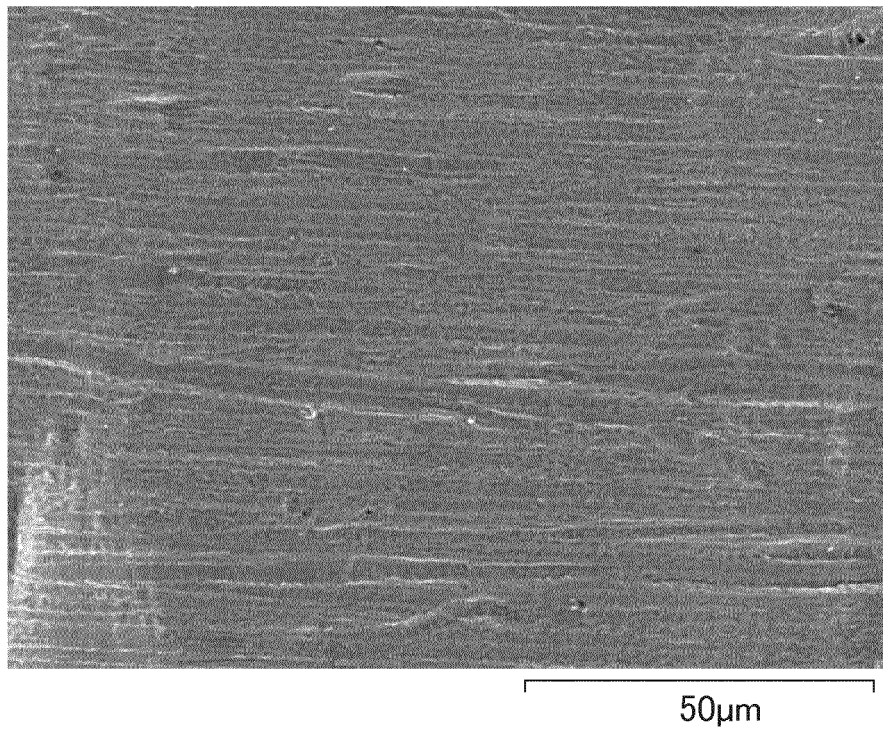


FIG. 5

FIG. 6B

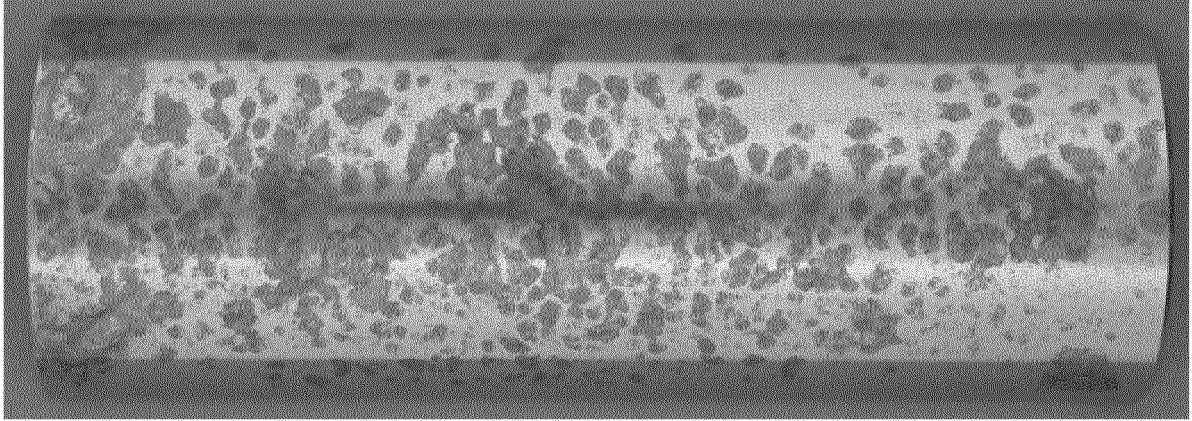
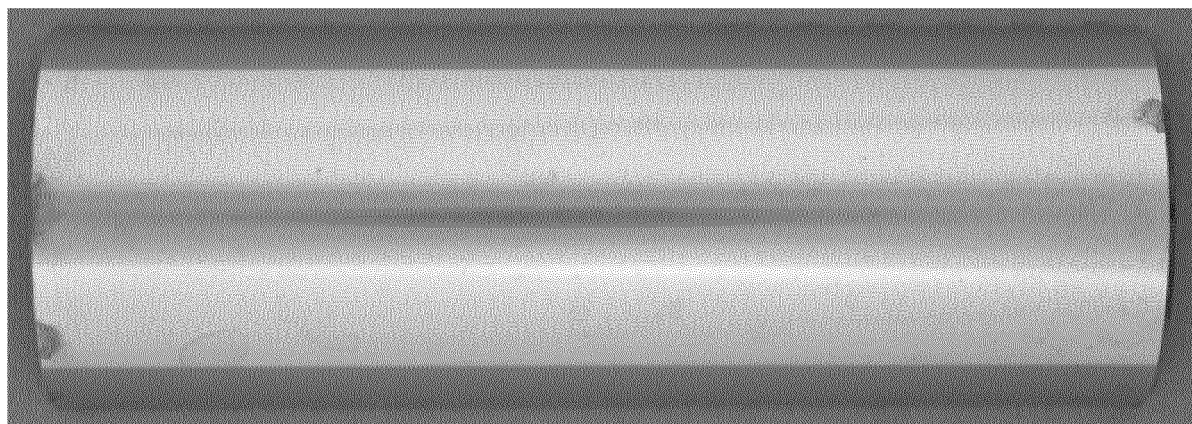


FIG. 6A



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/076142

A. CLASSIFICATION OF SUBJECT MATTER

B24B29/02(2006.01)i, B24B29/00(2006.01)i, B24B29/08(2006.01)i, C22C38/00(2006.01)n, C22C38/58(2006.01)n

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)

B24B3/00-3/60, B24B21/00-39/06, C22C38/00, C22C38/58

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 1996-2016

Kokai Jitsuyo Shinan Koho 1971-2016 Toroku Jitsuyo Shinan Koho 1994-2016

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

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2003-25209 A (Nisshin Steel Co., Ltd.), 29 January 2003 (29.01.2003), paragraphs [0008] to [0009], [0017] to [0018], [0025] to [0027]; fig. 4 (Family: none)	1-3
A	JP 2003-39309 A (Nisshin Steel Co., Ltd.), 13 February 2003 (13.02.2003), entire text (Family: none)	1-3
A	JP 2003-56755 A (Nisshin Steel Co., Ltd.), 26 February 2003 (26.02.2003), entire text (Family: none)	1-3

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

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Date of the actual completion of the international search
15 November 2016 (15.11.16)

Date of mailing of the international search report
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Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/076142

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 2009-50945 A (Nihon Micro Coating Co., Ltd.), 12 March 2009 (12.03.2009), entire text & US 2009/0054243 A1 entire text	1-3
A	JP 2004-209616 A (Ricoh Co., Ltd.), 29 July 2004 (29.07.2004), entire text (Family: none)	1-3
A	JP 2000-328045 A (C. Uyemura & Co., Ltd.), 28 November 2000 (28.11.2000), entire text (Family: none)	1-3

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2003056755 A [0007]