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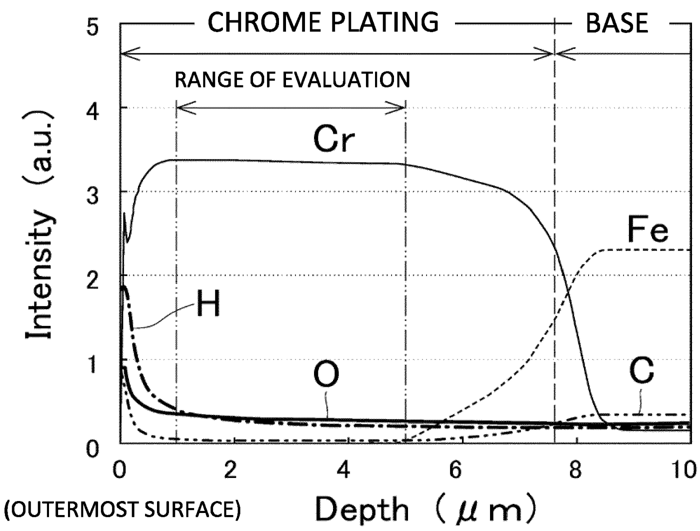
(54) **RING FOR FINE SPINNING MACHINE**

(57) A ring (11) for a fine spinning machine is used in the fine spinning machine for winding a yarn through a traveler (12) sliding on a sliding surface of the ring (11) in a dry state. The sliding surface of the ring (11) is covered by chrome plating (13). In the chrome plating (13), a ratio of emission intensity of hydrogen atoms (H) to emission intensity of chromium atoms (Cr) determined by glow discharge optical emission spectrometry (GD-OES) is 0.1 or more.

FIG. 2



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Description

BACKGROUND ART

[0001] The present disclosure relates to a ring for a fine spinning machine to prolong lifetime of the ring by improving abrasion resistance of the ring.

[0002] In the spinning process for producing yarn from raw cotton, as a nearly final stage thereof, a fine spinning process is performed. In the fine spinning process, roving produced in the roving spinning process is drawn out to have a predetermined thickness and is twisted and then is wound on a bobbin. The roving spinning process is performed mainly by a ring fine spinning machine. The ring fine spinning machine winds up a yarn through a traveler that glides (slides) on a ring that is supported by a ring rail and is movable up and down.

[0003] In order to improve the productivity of the spinning process (particularly the fine spinning process), the ring fine spinning machine can desirably be operated at a high speed for a long time. For the purpose, the lifetime of replacement of the ring and the traveler sliding under non-liquid lubrication (dry state) is required to extend. Japanese Patent Application Publication No. 2014-29046 discloses a ring and a traveler for a ring fine spinning machine to prolong lifetime of the ring and the traveler by improving abrasion resistance of the ring and the traveler.

[0004] The above Publication proposes to provide a hard chrome plating layer having micro cracks (recesses) on the sliding surface of the ring and the traveler for the ring fine spinning machine. In the above Publication, a fiber thin film having friction reducing effect on the sliding surface enters the micro cracks and becomes difficult to peel off, so that the sliding resistance of the traveler is stably reduced and the lifetime of the ring and the traveler is prolonged. However, the above Publication does not describe any composition, structure, and manufacturing method of the hard chrome plating layer.

[0005] Japanese Patent No. 4843318 and PCT international publication No. WO2010/119747 also describe chrome plating, but do not relate to a fine spinning machine and naturally, there is no description of rings and travelers. The chrome plating described therein is different from the chrome plating according to the present disclosure that will be described later.

[0006] The present disclosure, which has been made in light of such circumstances, is directed to providing a ring for a fine spinning machine, which can improve abrasion resistance of the ring and prolong lifetime of the ring by providing the sliding surface of the ring with chrome plating different from the conventional chrome plating.

SUMMARY

[0007] In accordance with an aspect of the present disclosure, there is provided a ring for a fine spinning machine, used in the fine spinning machine for winding a yarn through a traveler sliding on a sliding surface of the ring in a dry state. The sliding surface of the ring is covered by chrome plating. In the chrome plating, a ratio of emission intensity of hydrogen atoms to emission intensity of chromium atoms determined by glow discharge optical emission spectrometry is 0.1 or more.

[0008] Other aspects and advantages of the disclosure will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The disclosure together with objects and advantages thereof, may best be understood by reference to the following description of the embodiments together with the accompanying drawings in which:

FIG. 1A is a perspective view showing a ring for a fine spinning machine according to an embodiment of the present disclosure;

FIG. 1B is a partially enlarged perspective view showing the ring of FIG. 1A;

FIG. 1C is a schematic sectional view showing a sliding contact between the ring and a traveler during a spinning operation of the fine spinning machine of FIG. 1A;

FIG. 2 is a profile example (sample 1) obtained by measuring chrome plating with GD-OES;

FIG. 3 is X-ray diffraction profiles of the chrome plating of each sample;

FIG. 4 is photographs showing a sliding surface of each sample after a sliding test;

FIG. 5 is a scatter diagram showing the relationship between the hardness and the abrasion depth of the chrome plating of each sample;

FIG. 6A is a scatter diagram showing the relationship between H/Cr and the abrasion depth of the chrome plating of each sample;

FIG. 6B is a scatter diagram showing the relationship between C/Cr and the abrasion depth of the chrome plating of each sample;

FIG. 6C is a scatter diagram showing the relationship between O/Cr and the abrasion depth of the chrome plating of each sample;

FIG. 7 is a scatter diagram showing the relationship between the half-value width of (222) plane and the abrasion depth of the chrome plating of each sample;

FIG. 8 is a scatter diagram showing the relationship between the peak area ratio of (200)/(222) and the abrasion depth of the chrome plating of each sample;

FIG. 9 is a scatter diagram showing the relationship between the operation time of the actual machine and the abrasion depth of the chrome plating of each sample; and

FIG. 10 is a bar graph showing the lifetime ratio of the traveler incorporated with each ring.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0010] The inventors of the present disclosure have extensively examined the above-described problems in order to solve the problems. As a result, the inventors have found that by providing a specific chrome plating on a sliding surface of a ring in a fine spinning machine, abrasion resistance of the ring can improve and lifetime of a traveler that is a mating member of the ring can be prolonged. The inventors have developed the achievement and have completed the present disclosure described below.

Ring for a fine spinning machine

[0011]

(1) The present disclosure relates to a ring for a fine spinning machine to wind a yarn through a traveler sliding on the sliding surface of the ring in a dry state. The sliding surface is covered by chrome plating. In the ring for the fine spinning machine, the chrome plating is provided such that the ratio of the emission intensity of hydrogen atoms (H) to the emission intensity of chromium atoms (Cr) determined by glow discharge optical emission spectrometry (GD-OES) is 0.1 or more.

(2) The ring for the spinning machine according to the present disclosure (hereinafter referred to as ring) has excellent abrasion resistance because the abrasion of the ring is extremely small when the traveler glides in a dry state. Further, the ring in the present disclosure can suppress abrasion of the traveler that is a sliding mating member of the ring. Accordingly, in the present disclosure, the lifetime of the ring and the traveler can be prolonged to allow the ring spinning machine to operate at a high speed for a long time, so that the productivity of the fine spinning process can greatly improve.

(3) The reason why the ring in the present disclosure has such effects is inferred as follows. The chrome plating of the ring according to the present disclosure has a higher (relative) content of H than that in the conventional chrome plating covering the sliding surface of a ring, so that the crystal structure of the chrome plating becomes finer or the orientation becomes lower than that of the conventional chrome plating. It is considered that as a result, the abrasion resistance of the above-mentioned ring improves and the abrasion of the traveler is suppressed.

[0012] One or more components arbitrarily selected from the present specification may be added to the above-described components of the present disclosure. The contents described in the present specification are not limited to the ring for the fine spinning machine according to the present disclosure, but may be appropriately applied to a manufacturing method of the ring (especially, a method for forming chrome plating).

Ring and traveler

[0013] Referring to FIGS. 1A and 1B, a ring 11 for a ring spinning machine is shown. Referring to FIG. 1C, a traveler 12 for the ring spinning machine is shown with the ring 11. The ring 11 has a flange 11a having a substantially T-shaped cross section. The traveler 12 has a substantially C-shaped cross section and is slidably engaged with the flange 11a. The ring 11 and the traveler 12 are made of steel such as bearing steel. The ring 11 has a hard chrome plating film 13 on the surface (sliding surface) of the flange 11a. The chrome plating film 13 has a thickness of 3 μm to 20 μm, or further 5 μm to 15 μm.

[0014] As shown in FIG. 1C, a yarn Y delivered from a draft part (not shown in the drawing) passes through the traveler 12 and is wound on a bobbin (not shown in the drawing) rotating at a high speed. The traveler 12 glides while sliding on the chrome plating film 13 of the flange 11a by the winding tension of the yarn Y. Although the traveler 12 can slightly change the sliding attitude in accordance with the rotational speed thereof, in the normal spinning operation, as shown in FIG. 1C, the traveler 12 is in sliding contact with the lower inner side of the flange 11a. The maximum rotational speed of the spindle during the normal spinning operation is approximately 25000 rpm.

Chrome plating

[0015]

(1) In the film composition, the chrome plating contains at least H in addition to Cr as a main component. The ratio of the emission intensity of H to the emission intensity of Cr (hereinafter referred to as ratio H/Cr) can be 0.1 or more, 0.11 or more, 0.13 or more, or further 0.14 or more. When the amount of H becomes extremely small, microcrystallization and low orientation of the chrome plating become insufficient, so that the abrasion resistance of the chrome plating may decrease. The rate H/Cr may be 0.3 or less, or further 0.2 or less. When the amount of H becomes excessively large, the toughness of the film decreases and the abrasion resistance decreases.

[0016] The chrome plating may further include carbon atoms (C). C is considered to have less influence on the sliding characteristics of the chrome plating as compared to H. However, the ratio of the emission intensity of C to the emission intensity of Cr (hereinafter referred to as ratio C/Cr) may be 0.01 or more. It is considered that by coexisting of C and H, the chrome plating is solid-solution strengthened by Cr, so that the abrasion resistance of the chrome plating improves. Regarding the upper limit of the amount of C, the ratio C/Cr may be 0.03 or less, or further 0.02 or less. When the amount of C becomes excessively large, the chrome plating becomes amorphous and the toughness and the abrasion resistance of the chrome plating may decrease.

[0017] The chrome plating may further include oxygen atoms (O). O has little influence on the sliding characteristics of the chrome plating, but when O becomes excessively large, the hardness of the chrome plating decreases, so that the abrasion resistance of the chrome plating decreases. The ratio of the emission intensity of O to the emission intensity of Cr (hereinafter referred to as ratio O/Cr) may be 0.001 to 0.2, or further 0.005 to 0.15.

[0018] The composition analysis of chrome plating referred to in the present disclosure is specified as a ratio to the emission intensity to Cr as a main component by glow discharge optical emission spectrometry (GD-OES).

(2) In the film structure of the chrome plating, the half-value width of the peak of (222) plane determined by X-ray diffraction analysis (XRD) may be 3° or more, 3.5° or more, or further 4° or more. As the half-value width becomes larger, the crystallite diameter (size) of Cr determined from Scherrer's equation becomes smaller. That is, the chrome plating is microcrystallized. The half-value width means the full width at half maximum (FWHM) determined as the distance ($\Delta 2\theta$) between two points corresponding to half of the peak intensity of the XRD profile.

[0019] In the chrome plating, the area ratio (also referred to as peak area ratio) of the peak of (200) plane to the peak of (222) plane determined by XRD may be 0.06 or more, 0.07 or more, 0.1 or more, or further 0.15 or more. As the area ratio increases, the degree of orientation with respect to (222) plane of the Cr crystal becomes relatively lower. That is, the chrome plating has a lower orientation.

(3) In the film thickness, the chrome plating may have the film thickness of, for example, 3 μm to 20 μm, or further 10 μm to 15 μm. When the film thickness becomes excessively small, the abrasion resistance may decrease. When the film thickness becomes excessively large, the formation time of the chrome plating becomes undesirably long.

(4) In the film hardness, the chrome plating may have the film hardness of, for example, 850 HV to 1050 HV, or further 900 HV to 1000 HV. In the chrome plating according to the present disclosure, the hardness does not necessarily have a clear correlation with the abrasion resistance. However, when the hardness becomes excessively

small, the abrasion resistance of the ring may decrease. When the hardness becomes excessively large, the abrasion suppression of the traveler as a mating member of the ring may decrease.

Formation of chrome plating

[0020] Chrome plating is normally formed (film-formed) by electrolytic deposition or electroplating. A Sargent bath (ordinary bath), a fluoride bath (mixed catalyst bath), and a high-speed bath are used as the plating bath for chrome plating. The liquid composition of the Sargent bath is usually composed of chromic anhydride (CrO_3) and sulfuric acid (H_2SO_4). The fluoride bath usually contains fluoride (H_2SiF_6) in addition to chromic anhydride and sulfuric acid. The high-speed bath usually contains organic acids or organic catalysts in addition to chromic anhydride and sulfuric acid.

[0021] In order to efficiently form chrome plating, a high-speed bath may be used. The plating temperature when the high-speed bath is used may be adjusted within the range of 40°C to 70°C, or further 40°C to 50°C. The plating temperature depends on the liquid composition. The adjustment of the plating temperature permits to control the amount of H contained in the chrome plating. The plating temperature in the present disclosure is the liquid temperature of the plating bath.

[0022] The current density when using the high-speed bath may be adjusted within the range of 20 A/dm^2 to 90 A/dm^2, or further 50 A/dm^2 to 80 A/dm^2. When the current density becomes excessively small, the chrome plating cannot be efficiently formed. When the current density becomes excessively large, the formation of uniform chrome plating becomes difficult.

Others

[0023]

(1) The traveler sliding on the chrome plating of the ring is not limited in material, but the traveler may consist of carbon steel or alloy steel to secure the abrasion resistance (long lifetime). The traveler may consist of ordinary spring steel or high carbon steel and may be oxidized by heat treatment. By performing oxidation treatment, cohesion with a metal mating member (ring) is prevented.

(2) In a yarn (fiber), a yarn that slidably contacts with a traveler is not limited in types. The yarn may naturally supply lubricating components under non-liquid lubrication (dry state) in the atmosphere. That is, the yarn such as cotton, hemp, silk, wool, chemical fiber (nitrocellulose, nylon, or vinylon) is a desirable material for spinning operation.

EXAMPLES

Outline

[0024] The abrasion resistance of various chrome platings formed on steel materials (bases) used for the ring or the traveler of the ring spinning machine was evaluated by a ball-on disc friction test conducted under non-liquid lubrication (dry state) (basic test). In the ring spinning machine (hereinafter referred to as actual machine) having the ring having a flange surface covered by each chrome plating based on the results and the traveler, the abrasion resistance of each ring and the traveler was evaluated (actual machine test). The following will describe the details of the tests in the present disclosure.

Basic test for manufacturing samples

[0025]

(1) Disks (ϕ30 mm x 3 mm thick) and balls (ϕ6 mm) made of bearing steel (JIS SUJ2) used for the ring or the traveler of the ring spinning machine were prepared. The surface to be processed, of the disks for chrome plating had a surface roughness of Ra 0.08 μm by mirror finishing. The surface of the balls had a surface roughness of 0.08 μm Rzjis and a surface hardness of HV 800.

(2) Regarding chrome plating, one surface of the disk (surface roughness: Ra 0.08 μm) was covered by chrome plating. The chrome plating was performed by electroplating using a high-speed bath. Various chrome platings (films) having different film compositions (the amount of H and C) and different film structures were applied to the surface of the bases by controlling the liquid composition (specifically organic acid) of the high speed bath and the liquid temperature (plating temperature). Specifically, chrome platings containing a relatively large amount of H were film-formed by adjusting the liquid temperature to a lower level. Then, the description of the Japan Metal Society

Journal Vol. 68, No. 8 (2004) 552-557 was referenced. The film thickness of the chrome plating of each sample was set to 10 μm to 15 μm. The film thickness was determined by measuring abrasion marks after a sliding test described later using a coating thickness tester, the Calotest manufactured by CSM instruments.

(3) Regarding film composition, the composition of the chrome plating of each sample was specified by GD-OES using a Marcus type high-frequency glow discharge light emitting surface analyzer, GD-Profiler 2 manufactured by Horiba, Ltd. Referring FIG. 2, the analysis result of the sample 1 is shown as an example. The film composition was determined as the average value in the region (evaluation range) in which the respective element amounts (rates) were stable. Specifically, the ratios of the detected emission intensities of H, C and O to the emission intensity of the detected Cr as a reference were determined. TABLE 1 shows the film composition of each sample determined in the above way.

(4) Regarding film hardness, the hardness of the chrome plating of each sample was measured by a micro Vickers hardness tester. The measurement was performed with load at 300 g or less. The film hardness of each sample thus obtained is also shown in TABLE 1.

(5) Regarding film structure, the chrome plating of each sample was analyzed by XRD. Referring to FIG. 3, a part of each profile obtained by the analysis is shown. TABLE 1 also shows the half-value width of (222) plane and the area ratio of (200) / (222) of each sample determined from each profile.

[0026] XRD was performed using characteristic X-rays of CuKα (wavelength: λ = 1.5418 Å). The half-value width and the peak area ratio were calculated by image analysis of the profile determined by XRD. For the image analysis, peak fitting analysis by Voigt function was performed using an image processing software JADE 9.3 manufactured by MDI Co., Ltd., attached to an XRD apparatus, Ultima IV manufactured by Rigaku Corporation.

Sliding Test

[0027] The ball on disk test (hereinafter referred to as sliding test) was performed in which a ball is slid on a chrome-plated disk of each sample. The sliding conditions were as follows. The test load was 2 N (Hertz surface pressure: 210 MPa). The sliding velocity was 0.2 m / s. The test time was 50 minutes (sliding distance: equivalent to 600 m). The sliding environment was a non-lubrication state (a non-liquid lubrication state) in the atmosphere. Referring to FIG. 4, the sliding surfaces of the disks (chrome plating) and the balls of some samples after the sliding test are shown. The abrasion depth of each sample after the sliding test was measured with a laser microscope. The abrasion depth is defined as the distance from the non-sliding surface (smooth surface of chrome plating) to the deepest portion of the abrasion mark.

Evaluation

[0028]

(1) Regarding the abrasion resistance of the chrome plating, as shown in FIG. 4, the chrome plating of the sample 1 has an abrasion depth of 1/3 to 1/2 to the chrome platings of the sample C1 and the sample C2. The abrasion mark diameter on the mating member (ball) of the sample 1 also becomes smaller than that of the sample C1 or the sample C2. Accordingly, the chrome plating of the sample 1 has excellent abrasion resistance, low aggression to the mating member, and excellent sliding characteristics.

(2) Regarding the hardness of the chrome plating, referring to FIG. 5, the relationship between the hardness of the chrome plating and the abrasion depth of each sample shown in TABLE 1 is shown. As shown in FIG. 5, the samples (for example, the sample C2, the sample C3) having a sufficient hardness and a large abrasion depth exist. Therefore, the abrasion resistance of the chrome plating does not depend only on the hardness. However, all the chrome platings of the samples 1 to 4 having a small abrasion depth have a sufficient hardness.

(3) Regarding the composition of the chrome plating, referring to FIGS. 6A to 6C (hereinafter referred to as FIG. 6), the relationship between the chrome plating film composition (composition normalized by the amount of Cr) and the abrasion depth of each sample shown in TABLE 1 is shown. As shown in FIG. 6, the abrasion resistance of the chrome plating is greatly influenced by the amount of H among the elements that are contained in the chrome plating. Specifically, as shown in FIG. 6A, the chrome plating having high concentration of H is excellent in abrasion resistance.

[0029] As shown in FIG. 6B, as the amount of C contained in the chrome plating increases, the abrasion resistance generally tends to improve. However, a sample having a large amount of C and a large abrasion depth, such as the sample 3 exists. Accordingly, the influence of C on the abrasion resistance of the chrome plating is considered to be secondary. That is, the chrome plating having a large amount of H and a large amount of C is presumed to be excellent in abrasion resistance.

[0030] On the other hand, as shown in FIG. 6C, regardless of no great difference in the amount of O contained in the chrome platings among the respective samples, the abrasion depths greatly change. Therefore, the amount of O is presumed to have little influence on the abrasion resistance of the chrome plating.

(4) Regarding the structure of the chrome plating, as shown in FIG. 3, in the chrome plating of the sample 1 having a small abrasion depth, a large peak intensity is observed also in (200) plane in addition to (222) plane. In the sample C1 having a large abrasion depth, almost no peak relative to (200) plane is observed and a strong orientation to (222) plane is observed. Such a tendency is substantially the same as in the sample C3. As shown in FIG. 3, in the sample 1, the peak relative to (222) plane is broad and the half-value width is large, as compared to the sample C1 and the sample C3.

[0031] Referring to FIG. 7, the relationship between the half-value width of the peak of (222) plane and the abrasion depth of the samples shown in TABLE 1 is shown. Referring to FIG. 8, the relationship between the area ratio of the peak of (200) plane to the peak of (222) plane and the abrasion depth of the samples is shown.

[0032] As shown in FIG. 7, as the half-value width of (222) becomes large, the abrasion depth becomes small. That is, as the half-value width of the chrome plating becomes large, the chrome plating becomes excellent in abrasion resistance.

[0033] When the size of the crystallite (the largest collection that can be regarded as single crystal) of each sample is determined by the half-value width using the Scherrer's equation, for example, the sample 1 is 49 Å and the sample C1 is 81 Å. Accordingly, as the chrome plating microcrystallizes, the chrome plating is excellent in abrasion resistance.

[0034] As shown in FIG. 8, as the area ratio of (200) / (222) becomes large, the abrasion depth becomes small. As the area ratio becomes large, the orientation of the chrome plating relative to (222) plane becomes weak. That is, the degree of the orientation of the chrome plating decreases. Accordingly, as shown in FIG. 8, as the orientation of the chrome plating becomes low, the chrome plating becomes excellent in abrasion resistance.

[0035] As described above, as the amount of H becomes large and the chrome plating becomes microcrystallized and the orientation of the chrome plating becomes low, the chrome plating has excellent abrasion resistance, low aggression to the mating member, and excellent sliding characteristics.

Actual machine test

[0036]

(1) Regarding the test conditions, the actual machine test was performed using a ring spinning machine, RX 240 manufactured by Toyota Industries Corporation incorporating the chrome-plated ring relative to each sample and the traveler described above. As shown in FIG. 1, the outline of the ring and the traveler is shown. The film thickness of the chrome plating covering the flange portion of the ring is set to 10 μm or more. The actual machine was operated under a dry state at a maximum rotational speed of 21000 rpm.

(2) Regarding the test results, referring to FIG. 9, the time variation of the abrasion depth of each ring is shown. The ring subjected to the chrome plating of the sample 2 shows extremely excellent abrasion resistance because the abrasion depth is 0.1 μm or less after the operation time of 0.7 years. On the other hand, the rings subjected to the chrome platings of the sample C1 and the sample C2 have abrasion depths of 2 μm or more and 1.3 μm after the operation time was 0.7 years, respectively.

[0037] Referring to FIG. 10, the lifetime ratio of the traveler combined with the ring of each sample is shown. The lifetime ratio is shown as the reference of the lifetime of the traveler when using the ring of the sample C1. In the case of using the ring covered by the chrome plating of the sample 2, the traveler also has a greatly long lifetime.

[0038] As described above, when using the ring covered by the chrome plating according to the present disclosure, the abrasion resistance of the traveler improves as well as the ring, so that the ring and the traveler have a greatly long lifetime.

[0039] The chrome plating described in the present specification is so-called hard chrome plating, functional chrome plating, or industrial chrome plating (JIS).

[0040] A numerical range such as "x to y" as referred to in the present specification includes a lower limit value x and an upper limit value y unless otherwise specified. A numerical range such as "a to b" may be newly established with an arbitrary numerical value included in various numerical values or numerical ranges described in the present specification as a new lower limit value or upper limit value.

[0041] A ring (11) for a fine spinning machine is used in the fine spinning machine for winding a yarn through a traveler (12) sliding on a sliding surface of the ring (11) in a dry state. The sliding surface of the ring (11) is covered by chrome plating (13). In the chrome plating (13), a ratio of emission intensity of hydrogen atoms (H) to emission intensity of chromium atoms (Cr) determined by glow discharge optical emission spectrometry (GD-OES) is 0.1 or more.

TABLE 1

SAMPLE No.	FILM COMPOSITION (RATIO OF EMISSION INTENSITY DETERMINED BY GD-OES)			FILM STRUCTURE (X-RAY DIFFRACTION)		FILM HARDNESS (HV)	ABRASION DEPTH (μm)
	H	C	O	RATIO OF PEAK AREA (200)/(222)	HALF-VALUE WIDTH (°)		
1	0.1435	0.0115	0.0848	0.16	4.39	974	0.6
2	0.1147	0.0079	0.00865	0.065	3.90	942	0.9
3	0.1324	0.0110	0.0847	-	-	922	0.6
4	0.1772	0.0133	0.0945	-	-	912	0.7
C1	0.0746	0.0096	0.0845	0.00	2.65	752	1.1
C2	0.0784	0.0061	0.0738	0.06	3.82	914	1.5
C3	0.0705	0.0140	0.0714	0.013	3.21	866	2.1

Claims

1. A ring (11) for a fine spinning machine, wherein the ring (11) is used in the fine spinning machine for winding a yarn through a traveler (12) sliding on a sliding surface of the ring (11) in a dry state,
characterized in that the sliding surface of the ring (11) is covered by chrome plating (13), wherein in the chrome plating (13), a ratio of emission intensity of hydrogen atoms (H) to emission intensity of chromium atoms (Cr), determined by glow discharge optical emission spectrometry (GD-OES) is 0.1 or more.

2. The ring (11) for the fine spinning machine, according to claim 1, **characterized in that** in the chrome plating (13), a half-value width of a peak of a (222) plane, determined by X-ray diffraction analysis (XRD) is 3° or more.

3. The ring (11) for the fine spinning machine, according to claim 1 or 2, **characterized in that** in the chrome plating (13), an area ratio of a peak of (200) plane to the peak of (222) plane, determined by the X-ray diffraction analysis (XRD) is 0.06 or more.

4. The ring (11) for the fine spinning machine, according to any one of claims 1 to 3, **characterized in that** in the chrome plating (13), a ratio of emission intensity of carbon atoms (C) to the emission intensity of chromium atoms (Cr), determined by the glow discharge optical emission spectrometry (GD-OES) is 0.01 or more.

FIG. 1A

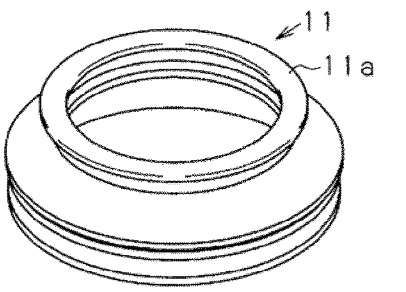


FIG. 1B

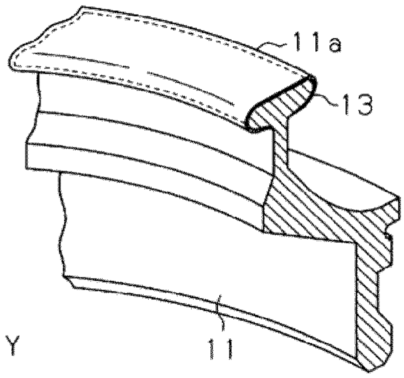


FIG. 1C

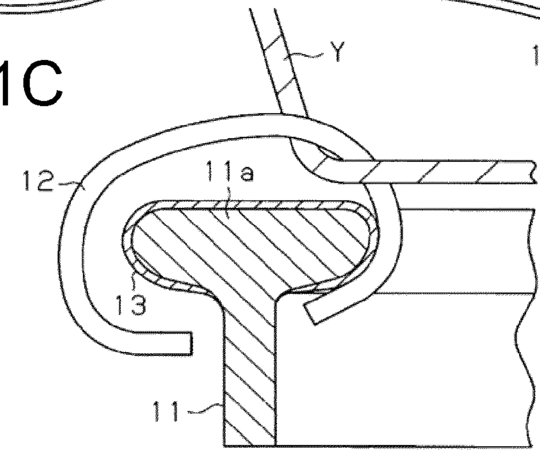


FIG. 2

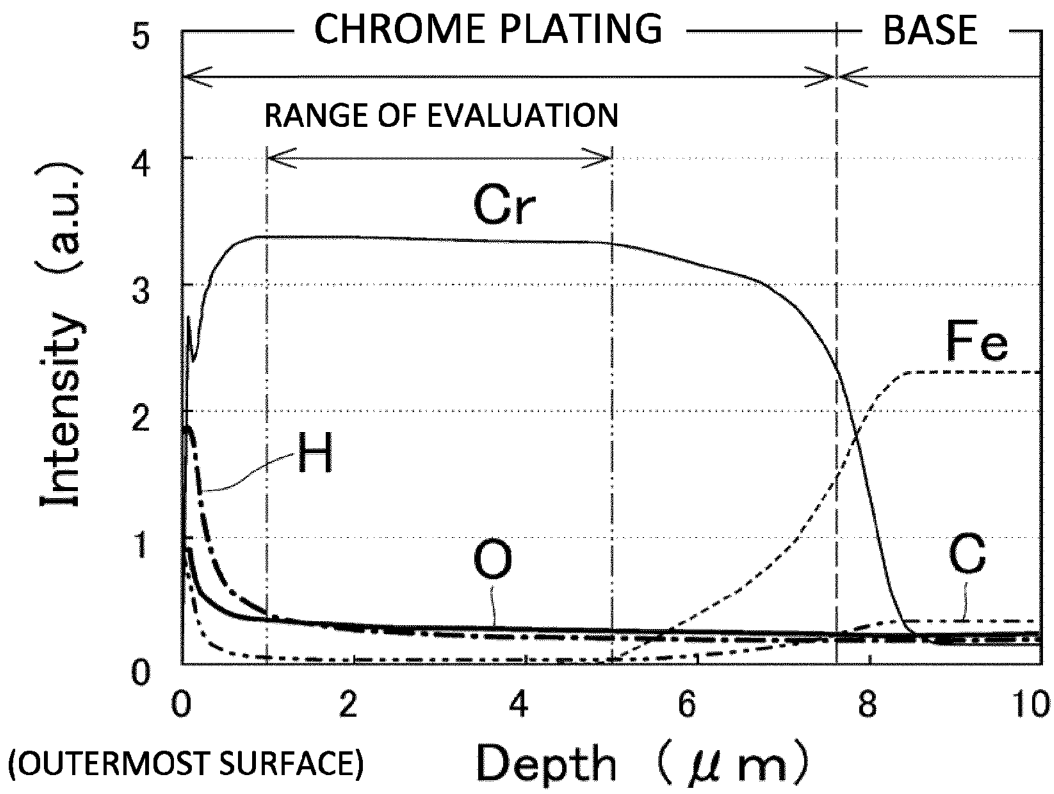
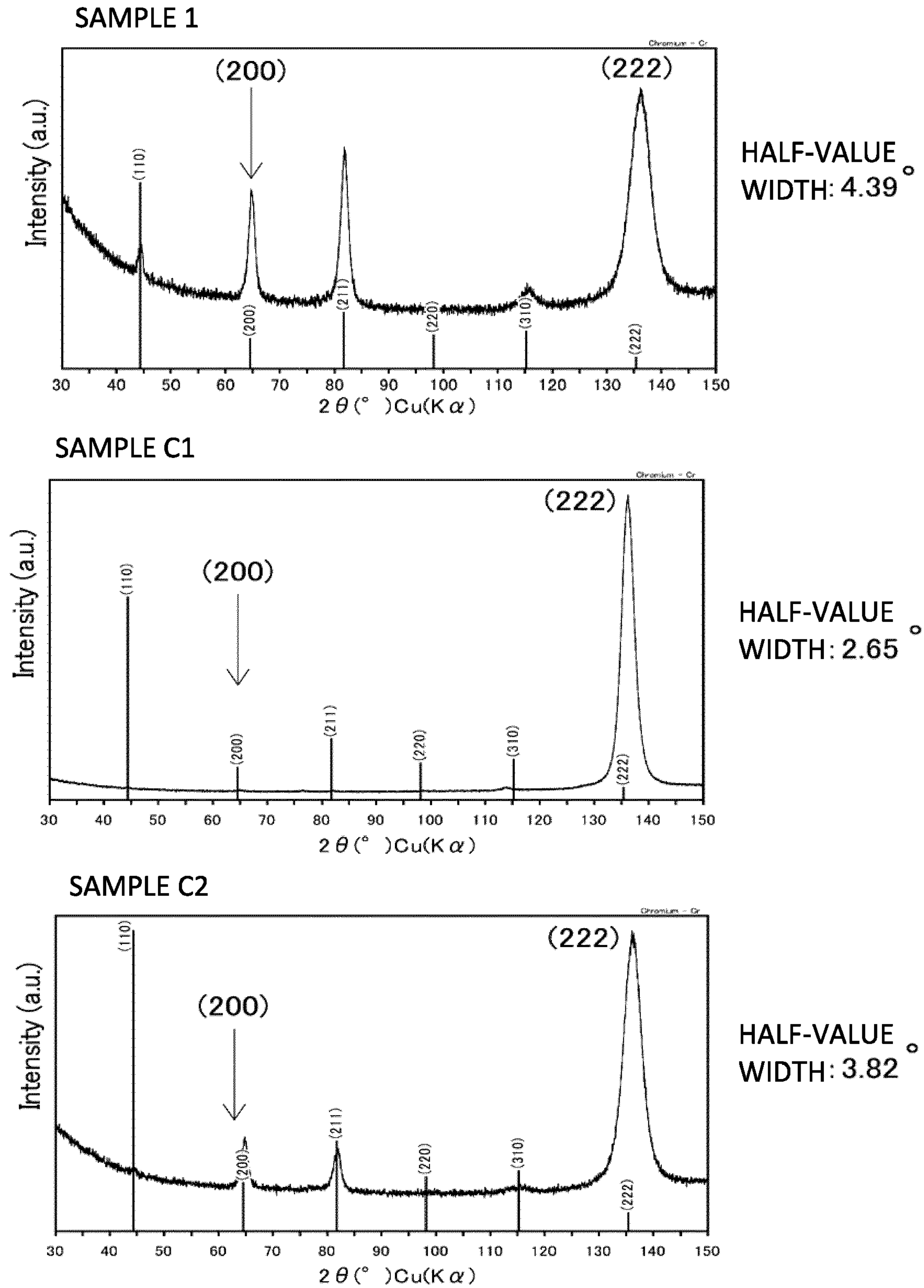


FIG. 3


SAMPLE 1
(200)
(222)
(110)
(200)
(211)
(220)
(310)
(222)
Intensity (a.u.)
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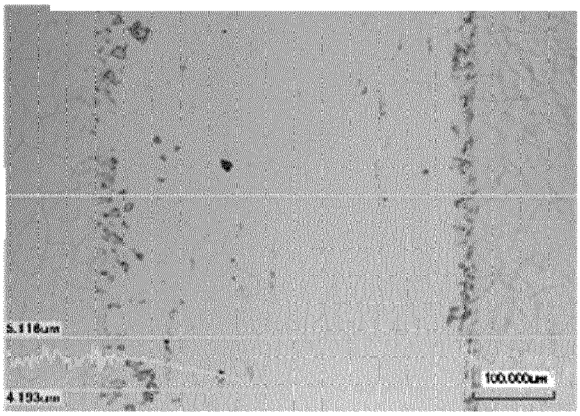
2θ(°)Cu(Kα)
HALF-VALUE WIDTH: 4.39°
SAMPLE C1
(222)
(200)
(110)
(200)
(211)
(220)
(310)
(222)
Intensity (a.u.)
30 40 50 60 70 80 90 100 110 120 130 140 150
2θ(°)Cu(Kα)
HALF-VALUE WIDTH: 2.65°
SAMPLE C2
(222)
(200)
(110)
(200)
(211)
(220)
(310)
(222)
Intensity (a.u.)
30 40 50 60 70 80 90 100 110 120 130 140 150
2θ(°)Cu(Kα)
HALF-VALUE WIDTH: 3.82°

FIG. 4

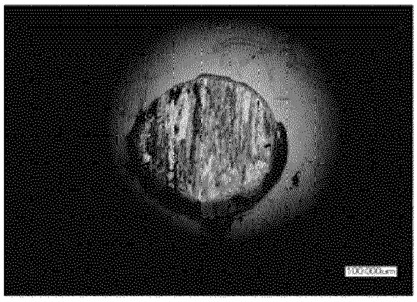
DISK
(CHROME PLATING)

BALL

SAMPLE 1

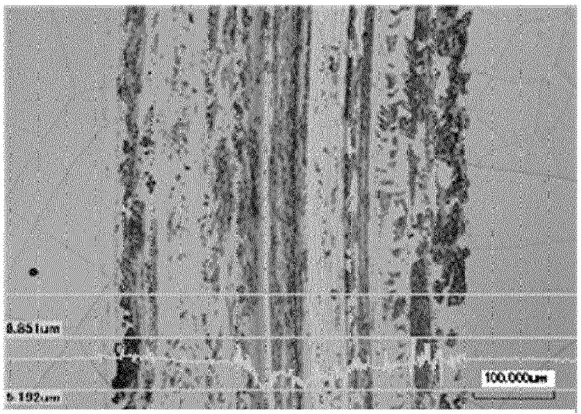


(ABRASION DEPTH: 0.6μm)

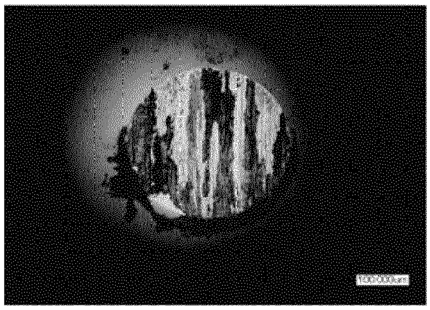


(ABRASION MARK
: 430μm)

SAMPLE C1

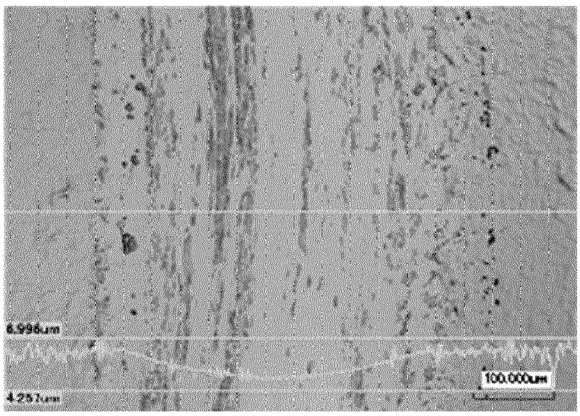


(ABRASION DEPTH: 1.1μm)

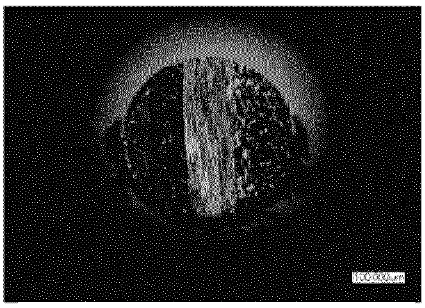


(ABRASION MARK
: 480μm)

SAMPLE C2



(ABRASION DEPTH: 1.5μm)



(ABRASION MARK
: 500μm)

FIG. 5

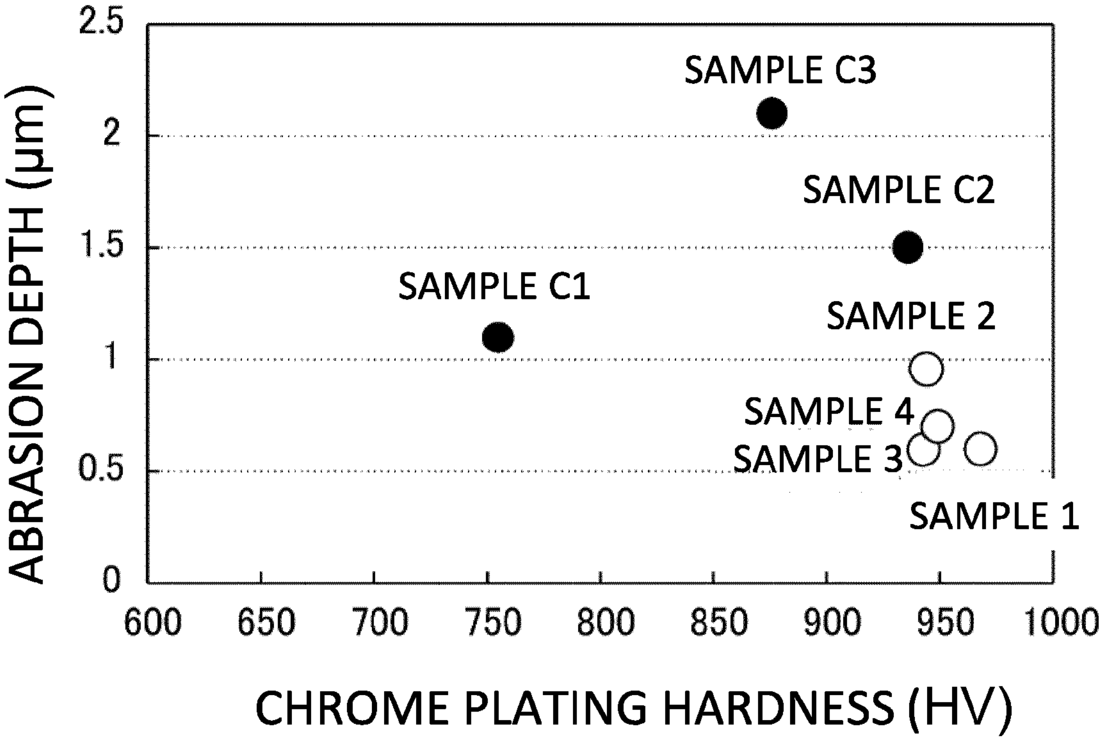

2.5
2
1.5
1
0.5
0
ABRASION DEPTH (μm)
SAMPLE C3
SAMPLE C2
SAMPLE C1
SAMPLE 2
SAMPLE 4
SAMPLE 3
SAMPLE 1
600
650
700
750
800
850
900
950
1000
CHROME PLATING HARDNESS (HV)

FIG. 6A

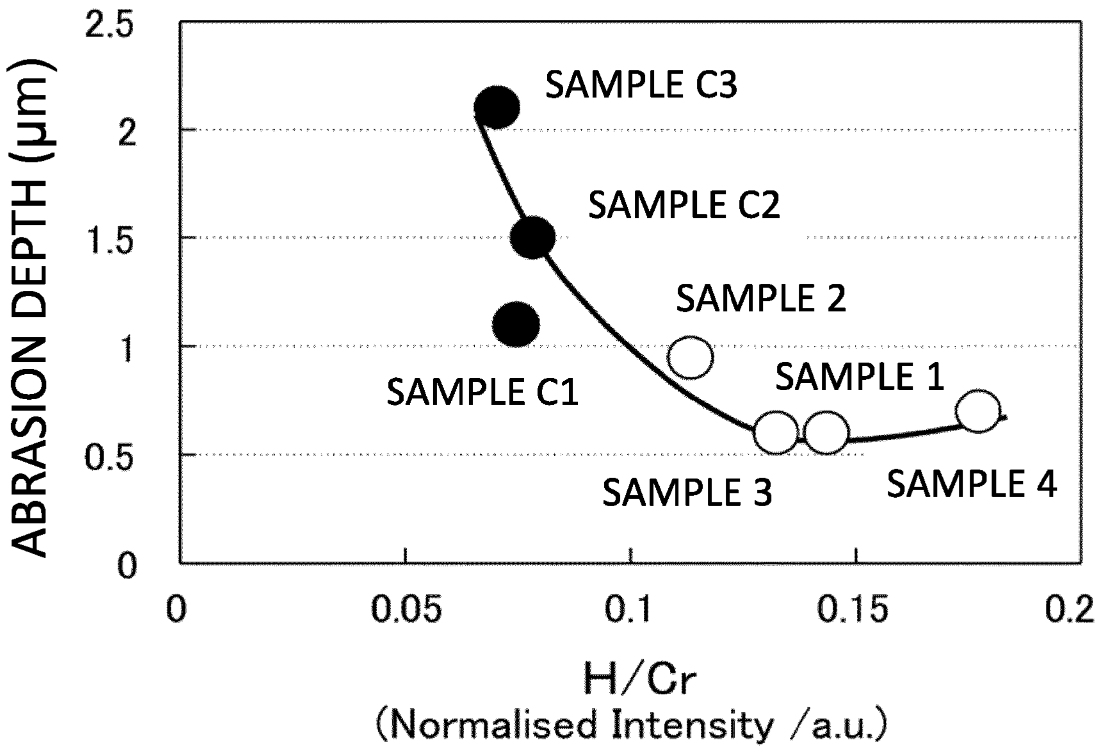

2.5
2
1.5
1
0.5
0
ABRASION DEPTH (μm)
SAMPLE C3
SAMPLE C2
SAMPLE 2
SAMPLE C1
SAMPLE 1
SAMPLE 3
SAMPLE 4
0
0.05
0.1
0.15
0.2
H/Cr
(Normalised Intensity /a.u.)

FIG. 6B

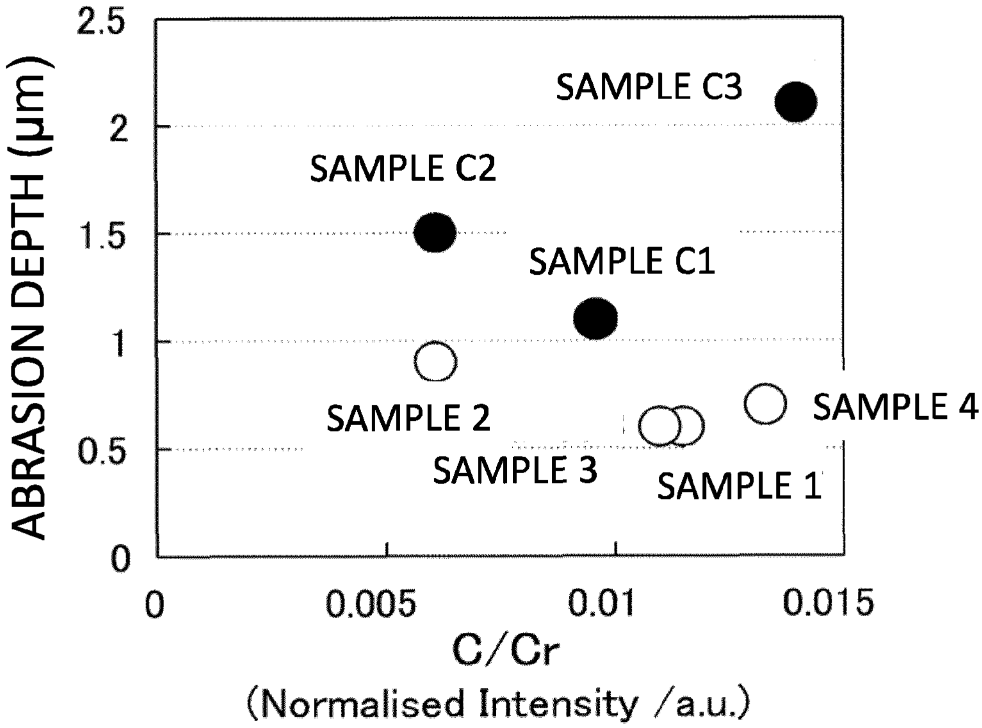

2.5
2
1.5
1
0.5
0
ABRASION DEPTH (μm)
SAMPLE C3
SAMPLE C2
SAMPLE C1
SAMPLE 2
SAMPLE 4
SAMPLE 3
SAMPLE 1
0
0.005
0.01
0.015
C/Cr
(Normalised Intensity /a.u.)

FIG. 6C

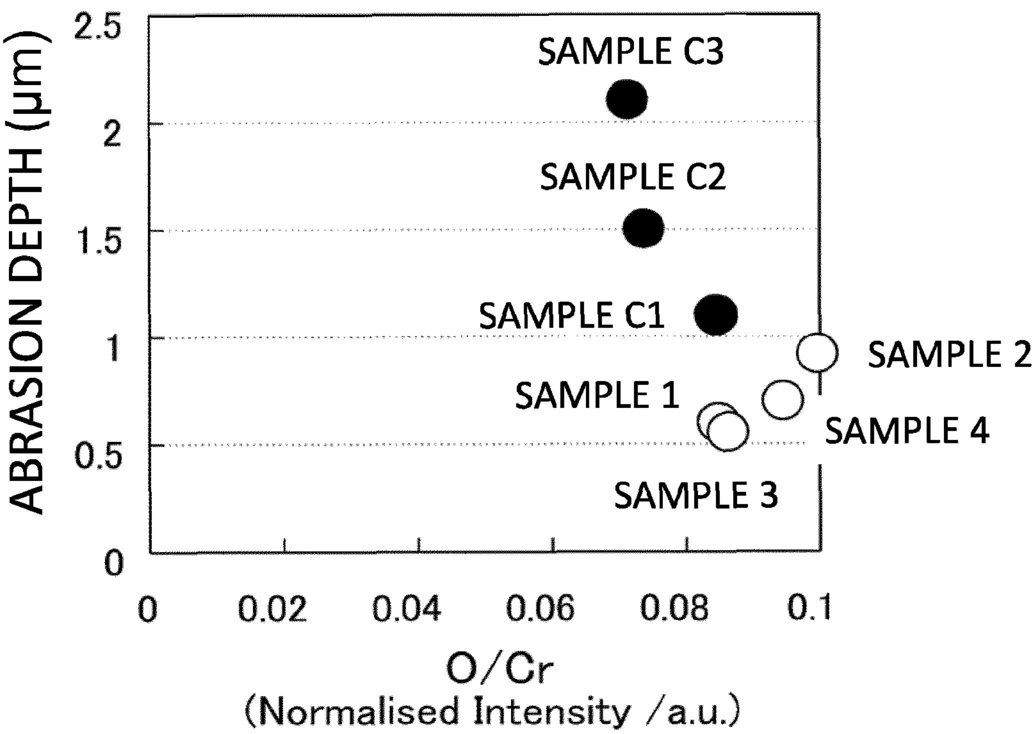

2.5
2
1.5
1
0.5
0
ABRASION DEPTH (μm)
SAMPLE C3
SAMPLE C2
SAMPLE C1
SAMPLE 2
SAMPLE 1
SAMPLE 4
SAMPLE 3
0
0.02
0.04
0.06
0.08
0.1
O/Cr
(Normalised Intensity /a.u.)

FIG. 7

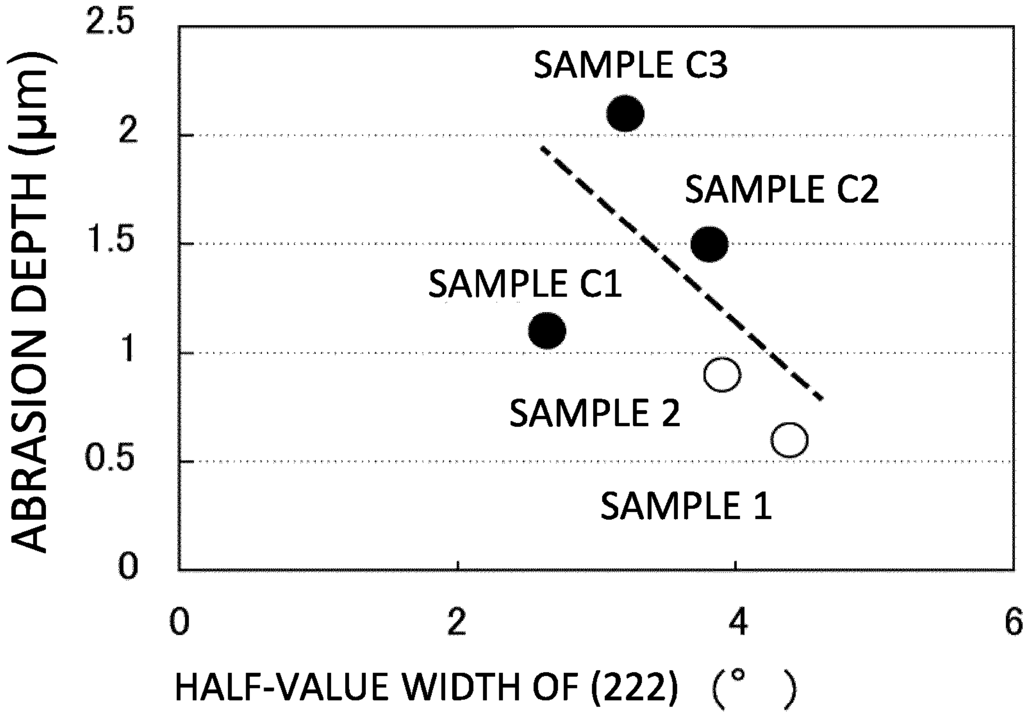

ABRASION DEPTH (μm)
2.5
2
1.5
1
0.5
0
SAMPLE C3
SAMPLE C2
SAMPLE C1
SAMPLE 2
SAMPLE 1
0
2
4
6
HALF-VALUE WIDTH OF (222) (°)

FIG. 8

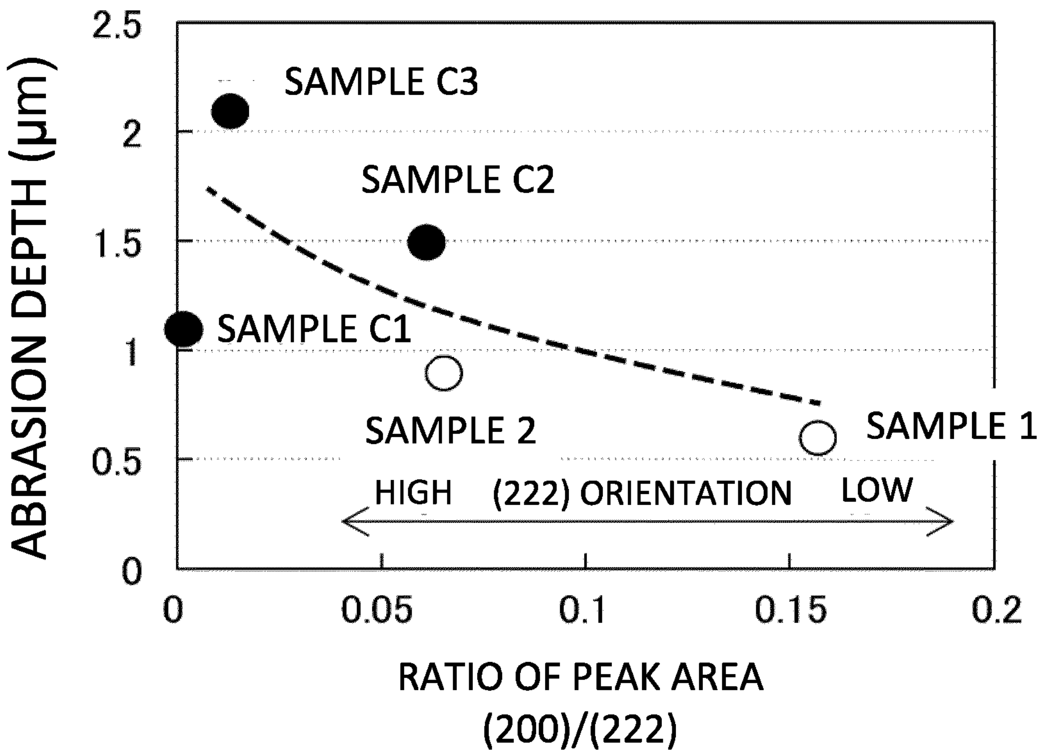

ABRASION DEPTH (μm)
2.5
2
1.5
1
0.5
0
SAMPLE C3
SAMPLE C2
SAMPLE C1
SAMPLE 2
SAMPLE 1
HIGH (222) ORIENTATION LOW
0
0.05
0.1
0.15
0.2
RATIO OF PEAK AREA
(200)/(222)

FIG. 9

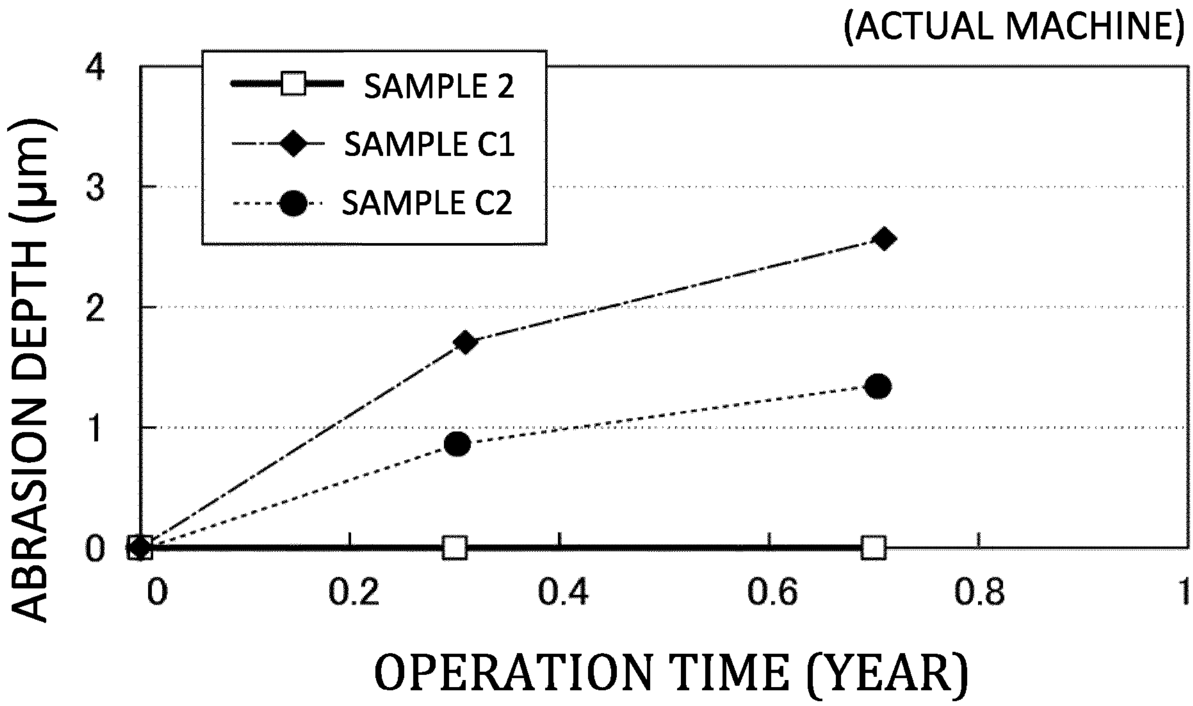
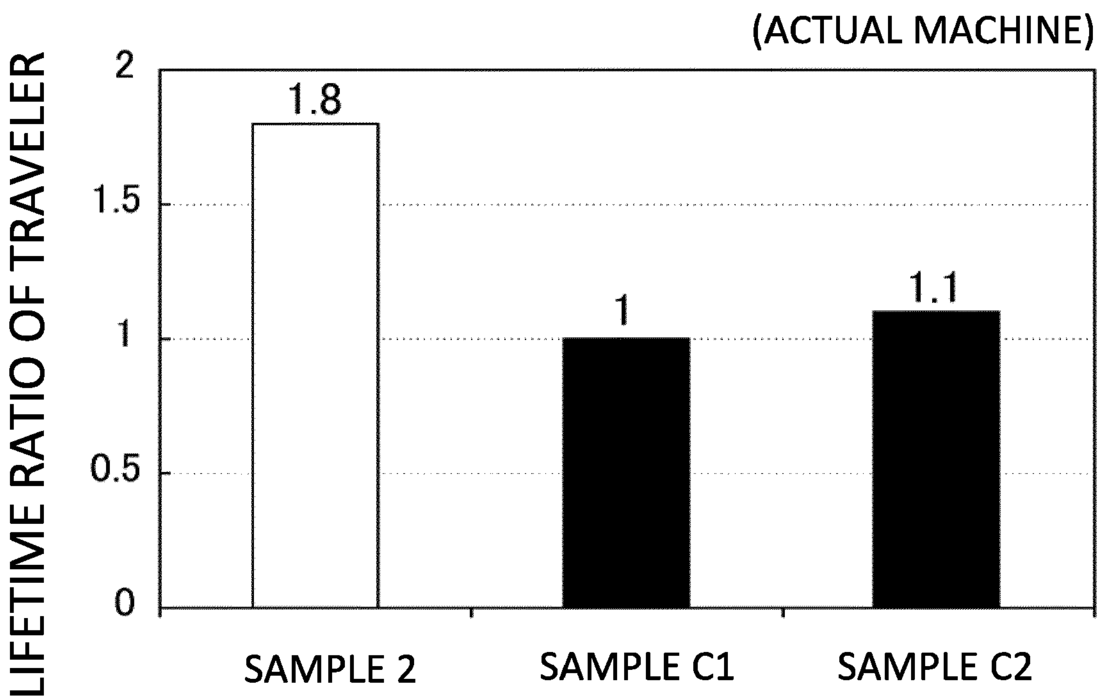

(ACTUAL MACHINE)
SAMPLE 2
SAMPLE C1
SAMPLE C2
ABRASION DEPTH (μm)
0
1
2
3
4
0
0.2
0.4
0.6
0.8
1
OPERATION TIME (YEAR)

FIG. 10


(ACTUAL MACHINE)
LIFETIME RATIO OF TRAVELER
0
0.5
1
1.5
2
1.8
1
1.1
SAMPLE 2
SAMPLE C1
SAMPLE C2

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EUROPEAN SEARCH REPORT

Application Number
EP 18 20 9991

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 5 829 240 A (BENSON RIO H [US] ET AL) 3 November 1998 (1998-11-03) * column 4, line 21 - column 5, line 14 * * figure 1 * -----	1-3	INV. D01H7/60 C25D7/04 ADD. C25D3/04
X	US 2001/047645 A1 (POQUETTE GEREON E [US] ET AL) 6 December 2001 (2001-12-06) * paragraphs [0029], [0037] - [0041] * * figure 1 * -----	1,4	
A	V-D HODOROABA: "Wasserstoffeffekt und -analyse in der GDS - Anwendungen in der Werkstoffforschung (Hydrogen Effect and Analysis in GDS - Applications in Material Science)", DISSERTATION TU DRESDEN [DE], 30 April 2002 (2002-04-30), pages 1-121, XP055250332, * page 105 * * figure 6-10 * -----	1-4	

TECHNICAL FIELDS SEARCHED (IPC)
C25D D01H

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
The Hague	15 May 2019	Le Hervet, Morgan

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- JP 4843318 B **[0005]**
- WO 2010119747 A **[0005]**

Non-patent literature cited in the description

- *Japan Metal Society Journal,* 2004, vol. 68 (8), 552-557 **[0025]**