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(71) Applicant: **KYOCERA Corporation**
Kyoto 612-8501 (JP)

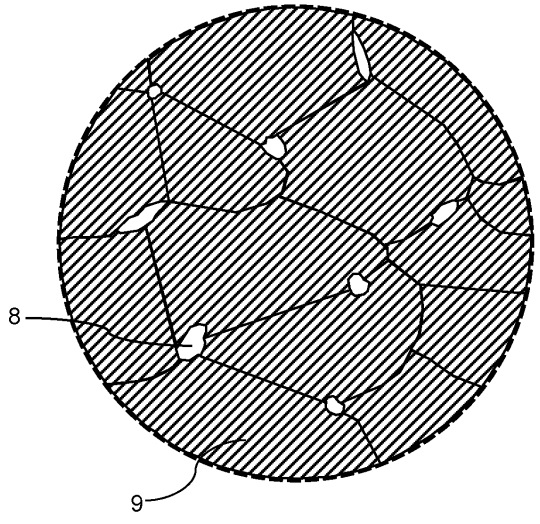
(72) Inventors:
- **IIDA, Shuichi**
  Kyoto-shi
  Kyoto 612-8501 (JP)
- **TOYODA, Satoshi**
  Kyoto-shi
  Kyoto 612-8501 (JP)
- **OOTA, Mizuho**
  Kyoto-shi
  Kyoto 612-8501 (JP)
- **TAKENOSHITA, Hidehiro**
  Kyoto-shi
  Kyoto 612-8501 (JP)

(74) Representative: **Viering, Jentschura & Partner mbB**
Patent- und Rechtsanwälte
Am Brauhaus 8
01099 Dresden (DE)

(54) FIBER GUIDE

(57) A fiber guide according to the present disclosure includes a base; and a fiber contact surface that is brought into contact with a fiber in at least part of the base. The fiber contact surface includes an aluminum oxide ceramic and includes a zirconium silicate phase between aluminum oxide crystals.

FIG.7



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Description

Field

[0001] The present disclosure relates to a fiber guide. Background

[0002] To guide a fiber, fiber guides having various shapes, which are called a roller guide, an oiling nozzle, a rod guide, a traverse guide, or a friction disk, are attached to a fiber machine while in use. As for a surface (hereinafter referred to as a fiber contact surface) of a fiber guide that is brought into contact with a fiber, there is a demand to prevent the occurrence of damage, such as scratch or looseness, to a fiber. There is also a demand for low manufacturing costs of fiber guides.

[0003] For these reasons, aluminum oxide ceramics, which are superior in abrasion resistance regardless of low costs, are often used as the material of a fiber guide.

[0004] For example, Patent Literature 1 discloses a guide that includes aluminum oxide and has a Vickers hardness HV of 1900 or more.

Citation List

Patent Literature

[0005] Patent Literature 1: Japanese Laid-open Patent Publication No. 2003-213522

Summary

Technical Problem

Solution to Problem

Brief Description of Drawings

[0006]

FIG. 1 is a perspective view of a roller guide to illustrate an example of a fiber guide according to the present disclosure.
FIG. 2 is a perspective view of an oiling nozzle to illustrate an example of the fiber guide according to the present disclosure.
FIG. 3 is a perspective view of a rod guide to illustrate an example of the fiber guide according to the present disclosure.
FIG. 4 is a perspective view of a traverse guide to illustrate an example of the fiber guide according to the present disclosure.
FIG. 5 is a perspective view of a friction disk to illustrate an example of the fiber guide according to the present disclosure.
FIG. 6 is a top view of the oiling nozzle illustrated in FIG. 2.
FIG. 7 is a schematic diagram that illustrates an example of a surface of the fiber guide according to the present disclosure.
FIG. 8 is a schematic view of a sliding testing device.

Description of Embodiments

[0007] In recent years, there has been an extreme increase in the delivering speed of fibers up to 1000 to 10000 m/minute to improve the productive efficiency of fibers. Therefore, there is a demand for a fiber guide having a fiber contact surface with a low friction coefficient, which is unlikely to give damage to fibers regardless of an increase in the delivering speed of fibers.

[0008] With the fiber guide according to the present disclosure, a fiber contact surface with a low friction coefficient may reduce the occurrence of damage to fibers while the fibers are guided. The fiber guide according to the present disclosure is described below in detail with reference to drawings.

[0009] First, the typical types of fiber guides are described with reference to FIGS. 1 to 5. First of all, a roller guide 10a illustrated in FIG. 1 guides a fiber 1 at a U-shaped groove portion while rotating. Then, an oiling nozzle 10b illustrated in FIG. 2 is used to apply oil to the fiber 1. Then, a rod guide 10c illustrated in FIG. 3 is used to bundle or separate the fibers 1. Then, a traverse guide 10d illustrated in FIG. 4 is used as a guide to wind the fiber 1 around the outer circumference of a cylindrical package. A friction disk 10e illustrated in FIG. 5 is used to twist the fiber 1.

[0010] FIG. 6 is a top view (the view in the direction of the arrow that is white with the black outline in FIG. 2) of the oiling nozzle 10b illustrated in FIG. 2. In the following description, the fiber guide is denoted by the reference numeral "10", except for the case where the specific fiber guide is described.

[0011] As illustrated in FIG. 6, the fiber guide 10 according to the present disclosure includes a base 11 and a fiber contact surface 2 that is brought into contact with the fiber 1 in at least part of the base 11. The fiber contact surface 2 is a surface of the fiber guide 10 that is brought into contact with the fiber 1 and, to discriminate it from the base 11, the fiber contact surface 2 is in the depth up to 0.2 mm from the surface that is brought into contact with the fiber 1. In FIG. 6, the fiber contact surface 2 is illustrated in color so as to be distinguished. The inlet side and the outlet side for the fiber 1 need to be clearly distinguished on the fiber contact surface 2, and the fiber contact surface 2 includes an inlet portion 3, an intermediate portion 4, and an outlet portion 5. The fiber guide including the fiber contact surface 2 including the inlet portion 3, the intermediate portion 4, and the outlet portion 5 is, for example, the oiling nozzle 10b illustrated in FIG. 2. The fiber contact surface 2 of the above-described oiling nozzle 10b includes a pair of a first end 6 and a second end 7 in a delivering direction of the fiber 1. The first end 6 is the portion of the fiber contact surface 2 with which the fiber 1 is first brought into contact at the inlet side of the fiber 1, and the second end 7 is the portion of the fiber contact surface 2 with which the fiber 1 is in contact up to the end at the outlet side of the fiber 1. The inlet portion 3 refers to, when the entire length of the fiber contact surface 2 is from the first end 6 to the second end 7, the portion of 1/5 of the entire length from the first end 6. Conversely, the outlet portion 5 refers to the portion of 1/5 of the entire length from the second end 7. The portion of the fiber contact surface 2 between the inlet portion 3 and the outlet portion 5 is the intermediate portion 4.

[0012] The fiber contact surface 2 of the fiber guide 10 according to the present disclosure includes an aluminum oxide ceramic and, as illustrated in FIG. 7, includes a zirconium silicate phase 8 between aluminum oxide crystals 9.

[0013] In the aluminum oxide ceramic, out of 100 mass-% of all the components included in the aluminum oxide ceramic, aluminum oxide occupies 80 or more mass-%.

[0014] The material of the fiber contact surface 2 may be confirmed in the following method. First of all, measurement is conducted on the fiber contact surface 2 by using an X-ray diffraction device (XRD), and identification is executed by using the JCPDS card based on the obtained value of 2θ (2θ is a diffraction angle). Subsequently, quantitative analysis is conducted on components contained in the fiber contact surface 2 by using a fluorescence X-ray analysis device (XRF). Subsequently, an aluminum oxide ceramic is determined when the presence of aluminum oxide is confirmed during the identification by the above-described XRD and the content of aluminum oxide (Al_2O_3), converted from the content of aluminum (Al) measured by the above-described XRF, is 80 or more mass-%.

[0015] The zirconium silicate phase 8 has a low friction coefficient as compared with the aluminum oxide crystal 9. In the fiber guide 10 according to the present disclosure, as the zirconium silicate phase 8 is provided between the aluminum oxide crystals 9, the fiber contact surface 2 has a low friction coefficient.

[0016] The presence or absence of the zirconium silicate phase 8 in the fiber contact surface 2 may be determined in the following method.

[0017] First of all, by using an Electron Probe Micro Analyzer (EPMA), elemental mapping is executed on the area that is recognized as a phase present between the aluminum oxide crystals 9. If zirconium, silicon, and oxygen are simultaneously detected during the elemental mapping, it is determined that the fiber guide 10 according to the present disclosure includes the zirconium silicate phase 8. As the aluminum oxide layer 9 is present under the zirconium silicate phase 8, aluminum may be detected even when no aluminum oxide is included between the aluminum oxide crystals 9.

[0018] FIG. 7 schematically illustrates a state of the fiber contact surface 2 observed by a Scanning Electron Microscope (SEM), or the like. The color relation in FIG. 7 is based on an SEM image (picture); the zirconium silicate phase 8 exhibits a white-based color, and the aluminum oxide crystal 9 exhibits a black-based color, whereby the zirconium silicate phase 8 and the aluminum oxide crystal 9 may be visually discriminated.

[0019] In the fiber guide 10 according to the present disclosure, the base 11 and the fiber contact surface 2 include an integrated aluminum oxide ceramic, and the percentage of the area occupied by the zirconium silicate phase 8 in the fiber contact surface 2 may be higher than the percentage of the area occupied by the zirconium silicate phase 8 inside the base 11. The inside of the base 11 refers to a portion in the depth of 0.2 or more mm from the surface of the base 11. The material of the base 11 may be confirmed in the same method as the above-described method for confirming the material of the fiber contact surface 2.

[0020] The heat conductivity of the zirconium silicate phase 8 is approximately 3 to 8 W/m·K. Conversely, the heat conductivity of the aluminum oxide crystal 9 is approximately 15 to 40 W/m·K. Therefore, when the above-described configuration is satisfied, the fiber contact surface 2 having a higher percentage of the area occupied by the zirconium silicate phase 8 as compared with the base 11 has a lower heat conductivity than that of the inside of the base 11; thus, the friction heat generated in the fiber contact surface 2 during the delivery of the fiber 1 is diffused into the inside of the base 11 having a higher heat conductivity so that an increase in the temperature of the fiber contact surface 2 may be suppressed. Thus, in the fiber guide 10 according to the present disclosure, damage such as scratch or looseness are unlikely to occur in the fiber 1 even though the fiber 1 is guided for a long period of time. In other words, the friction

coefficient of the fiber contact surface 2 may be maintained.

[0021] In the fiber guide 10 according to the present disclosure, the percentage of the area occupied by the zirconium silicate phase 8 in the fiber contact surface 2 may be higher than the percentage of the area occupied by the zirconium silicate phase 8 inside the base 11 by 0.2 or more area-%. When this configuration is satisfied, the friction coefficient of the fiber contact surface 2 may be further maintained in the fiber guide 10 according to the present disclosure even though the fiber 1 is guided for a long time of period.

[0022] The percentage of the area occupied by the zirconium silicate phase 8 in the fiber contact surface 2 may be, for example, 0.2 or more area-% and 1.8 or less area-%. The percentage of the area occupied by the zirconium silicate phase 8 inside the base 11 is, for example, 0.1 or less area-% and may be 0 area-%, in which the zirconium silicate phase 8 is not present.

[0023] The percentage of the area occupied by the zirconium silicate phase 8 in the fiber contact surface 2 and inside the base 11 may be calculated in the following method. First of all, backscattered electron image (BEI) pictures (hereafter simply referred to as pictures) of the fiber contact surface 2 and the inside of the base 11 are taken by using the SEM. As the zirconium silicate phase 8 exhibits a white-based color as described above, image analysis is performed on the picture by applying a particle analysis technique of the image analysis software "A-zo Kun" (registered trademark, manufactured by Asahi Kasei Engineering Corporation; when the image analysis software "A-zo Kun" is described below, it indicates the image analysis software manufactured by Asahi Kasei Engineering Corporation) so that the percentage of the area occupied by the zirconium silicate phase 8 may be obtained.

[0024] The percentage of the area occupied by the zirconium silicate phase 8 in the fiber contact surface 2 is the average value of the image analysis on six or more pictures at different areas of the fiber contact surface 2 captured at 1000 to 3000 magnification. As the contact surface 2 includes the inlet portion 3, the intermediate portion 4, and the outlet portion 5, the image analysis is conducted on two pictures at each of the different areas in the inlet portion 3, the intermediate portion 4, and the outlet portion 5, and the average value may be the percentage of the area occupied by the zirconium silicate phase 8 in the fiber contact surface 2.

[0025] The percentage of the area occupied by the zirconium silicate phase 8 inside the base 11 is the average value of the image analysis on six or more pictures at different areas inside the base 11 captured at 1000 to 3000 magnification.

[0026] Examples of the analysis conditions of "A-zo Kun" include, but are not limited to, "bright" for the brightness of a crystal particle, "manual" for the method for binarization, "present" for shading, etc., and a threshold may be set so as to clearly distinguish between the zirconium silicate phase 8 and the aluminum oxide crystal 9.

[0027] On the fiber contact surface 2 of the fiber guide 10 according to the present disclosure, the percentage of the area occupied by the zirconium silicate phase 8 in the inlet portion 3 may be higher than the percentage of the area occupied by the zirconium silicate phase 8 in the intermediate portion 4. When this configuration is satisfied, the inlet portion 3, which is a portion where the fiber 1 is most likely to be damaged, may have low frictional resistance. In the fiber guide 10 according to the present disclosure, the percentage of the area occupied by the zirconium silicate phase 8 in the inlet portion 3 included in the fiber contact surface 2 may be 0.3 or more area-% and 2.5 or less area-%.

[0028] The percentage of the area occupied by the zirconium silicate phase 8 in the inlet portion 3 and the intermediate portion 4 may be calculated by the particle analysis of the image analysis software "A-zo Kun" in the same manner as the above-described method for calculating the percentage of the area occupied by the zirconium silicate phase in the fiber contact surface 2 and inside the base 11. Specifically, the percentage of the area occupied by the zirconium silicate phase 8 in the inlet portion 3 is the average value of the image analysis on two or more pictures at different areas of the inlet portion 3 captured at 1000 to 3000 magnification. The percentage of the area occupied by the zirconium silicate phase 8 in the intermediate portion 4 is the average value of the image analysis on two or more pictures at different areas of the intermediate portion 4 captured at 1000 to 3000 magnification.

[0029] In the fiber guide 10 according to the present disclosure, the average value of the equivalent circle diameter of the zirconium silicate phase 8 in the fiber contact surface 2 may be 0.6 or more μm and 3.2 or less μm. The equivalent circle diameter refers to the diameter of the circle when the zirconium silicate phase 8 is converted into the circle having the same size. When this configuration is satisfied, the zirconium silicate phase 8 is unlikely to be removed from the fiber contact surface 2 so that the friction coefficient of the fiber contact surface 2 may be further maintained.

[0030] The average value of the equivalent circle diameter of the aluminum oxide crystal 9 is, for example, 10 or more μm and 25 or less μm.

[0031] The average value of the equivalent circle diameter of each of the zirconium silicate phase 8 and the aluminum oxide crystal 9 may be calculated in the same method as the above-described method for calculating the percentage of the area occupied by the zirconium silicate phase in the fiber contact surface 2.

[0032] Then, the method for measuring the friction coefficient of the fiber contact surface 2 is described with reference to FIG. 8. A sliding testing device illustrated in FIG. 8 is a device that includes a roller R1, a roller R2, the fiber guide 10, a roller R3, and a roller R4 so as to guide the fiber 1 in this order. The roller R2 and the roller R3 are coupled to tension detectors (not illustrated).

[0033] Calculation is performed according to Amonton's Law equation (μ={lnT2-T1)}/θ) by using the measured value

of tension T1 detected by the tension detector of the roller R2 and the measured value of tension T2 detected by the tension detector of the roller R3 while the fiber 1 is guided by using the sliding testing device so as to obtain a friction coefficient (μ).

[0034] The friction coefficient changes in accordance with a testing condition, such as the type of the fiber 1, the form of the fiber 1, the delivering speed of the fiber 1, the tensional force of the fiber 1, or θ. For this reason, the comparison between friction coefficients needs to be performed under the same testing condition.

[0035] Then, an example of the method for producing the fiber guide 10 according to the present disclosure is described. Among the fiber guides 10, the oiling nozzle 10b is described as an example. In an example of the case described, the base 11 and the fiber contact surface 2 include an integrated aluminum oxide ceramic.

[0036] First of all, aluminum oxide (Al_2O_3) powders, a sintering agent, and a solvent are put into a mill together with a ball and is smashed to have predetermined granularity so as to produce a slurry. To obtain the fiber guide 10 having the zirconium silicate phase 8 inside the base 11, zirconium silicate ($ZrSiO_4$) powders may be doped when a slurry is produced.

[0037] Subsequently, after the obtained slurry is doped with a binder, spray drying is conducted by using a spray drier to produce granular powders.

[0038] Subsequently, the granular powders, thermoplastic resin, wax, and the like, are put into a kneader and mixed while heated to obtain a paste. The obtained paste is put into a pelletizer to obtain pellets that are the material for injection molding (injection molding). Subsequently, the obtained pellets are put into an injection molding machine (injection molding machine) for injection molding so as to obtain a compact shaped like an oiling nozzle. To obtain a compact shaped like an oiling nozzle, a mold for obtaining an oiling nozzle shape may be manufactured according to a typical injection molding technique and may be placed in the injection molding machine for injection molding.

[0039] Subsequently, the obtained compact is sintered in the air atmosphere at the highest temperature of 1500 or more °C and 1600 or less °C and in the retention time of two or more hours and five or less hours at the highest temperature to obtain a sinter. As the sintering condition, such as the highest temperature or the retention time, changes in accordance with the shape and the size of a product, they may be adjusted as appropriate.

[0040] Subsequently, the sinter, abrasive media, and water are put into a wet barrel finishing machine, and barrel finishing is performed. At this point, zirconium silicate powders have been mixed with water; therefore, when the media collides with the sinter during barrel finishing, the zirconium silicate powders enter the gap between the aluminum oxide crystals 9 so as to adhere to the surface of the sinter as the zirconium silicate phase 8.

[0041] After the barrel finishing, the sinter is cleaned and dried to obtain the oiling nozzle 10b according to the present disclosure.

[0042] The percentage of the area occupied by the zirconium silicate phase 8 in the fiber contact surface 2 and inside the base 11 may be controlled to have any value by adjusting the amount of zirconium silicate powders doped to produce a slurry, the amount of zirconium silicate powders mixed with water during barrel finishing, and the time period of the barrel finishing.

[0043] The percentage of the area occupied by the zirconium silicate phase 8 in the inlet portion 3 and the intermediate portion 4 of the fiber contact surface 2 may be controlled to have any value by adjusting the amount of zirconium silicate powders mixed with water during barrel finishing and the time period of the barrel finishing and by executing barrel finishing while masking parts of the inlet portion 3 and the intermediate portion 4 of the fiber contact surface 2.

[0044] The average particle diameter of the zirconium silicate powder used may be adjusted so that the average value of the equivalent circle diameter of the zirconium silicate phase 8 in the fiber contact surface 2 becomes 0.6 or more μm and 3.2 or less μm.

[First Embodiment]

[0045] Oiling nozzles were manufactured, which were different depending on the presence or absence of a zirconium silicate phase in a fiber contact surface. A sliding test was conducted on the oiling nozzles to compare the friction coefficients of fiber contact surfaces.

[0046] First of all, aluminum oxide powders, titanium oxide (TiO_2) powders and magnesium carbonate ($MgCO_3$) powders as sintering agents were prepared. The powders were weighted and mixed such that the aluminum oxide powders were 98.4 mass-%, the titanium oxide powders were 1 mass-%, and the magnesium carbonate powders were 0.6 mass-% in terms of magnesium oxide (MgO). Subsequently, they were put into a mill together with water, which was a solvent, and a ball to be ground so as to produce a slurry.

[0047] Subsequently, after the slurry was doped with a binder, spray drying was performed using a spray drier to produce granular powders.

[0048] Subsequently, the granular powders, thermoplastic resin, and wax were additionally put into a kneader and mixed while heated to obtain a paste. The obtained paste was put into a pelletizer to obtain pellets that were the material for injection molding. Subsequently, the obtained pellets were put into an injection molding machine for injection molding

so as to obtain a compact shaped like an oiling nozzle.

[0049] Subsequently, the compact was sintered in the air atmosphere at the highest temperature of 1550 °C and in the retention time of three hours at the highest temperature to obtain a sinter.

[0050] Subsequently, the sinter, abrasive media, and water were put into a wet barrel finishing machine and were subjected to barrel finishing for two hours. At this point, during the barrel finishing, zirconium silicate powders having an average particle diameter of 3.5 μm were mixed with water such that the amount to be doped was 0.015 mass-% with respect to 100 mass-% of the total amount of water and zirconium silicate powders.

[0051] Subsequently, the sinter was cleaned and dried to obtain a sample No. 1.

[0052] In the above-described production method, barrel finishing was conducted by using water that was not mixed with zirconium silicate powders to obtain a sample No. 2.

[0053] Subsequently, each sample was set in the sliding testing device illustrated in FIG. 8 and was subjected to a sliding test to obtain the friction coefficient of each sample. The measurement conditions were as follows:

Type of fiber: nylon (75 denier)
Delivering speed of fiber: 1500 m/minute
θ: 90°
Tensional force of fiber: 50 gf
Measurement frequency: 10 times (every one minute)
Friction coefficient: a friction coefficient was determined from each detected tension and the average value in ten times was obtained as a friction coefficient.

[0054] Table 1 illustrates the results.

Table 1

SAMPLE NO.	PRESENCE OR ABSENCE OF ZIRCONIUM SILICATE PHASE	FRICTION COEFFICIENT μ
1	PRESENT	0.36
2	ABSENT	0.45

[0055] According to the results illustrated in Table 1, the sample No. 1 had a low friction coefficient of 0.36 as compared with the sample No. 2. This indicates that, when the fiber contact surface includes the zirconium silicate phase, the fiber contact surface has a low friction coefficient.

[Second Embodiment]

[0056] Then, oiling nozzles having different percentages of the area occupied by the zirconium silicate phase in the fiber contact surface and inside the base were produced. A sliding test was conducted on the oiling nozzles to compare the friction coefficients of the fiber contact surfaces.

[0057] The production method was the same as the method for producing the sample No. 1 according to the first embodiment except that the amount of zirconium silicate powders illustrated in Table 2 was doped to produce a slurry and the amount of zirconium silicate powders illustrated in Table 2 was doped and mixed with water during barrel finishing, and a sample No. 5 was the same as the sample No. 1 according to the first embodiment. When the slurry was doped with zirconium silicate powders, the amount of aluminum oxide powders to be doped was reduced by the amount of zirconium silicate powders doped.

[0058] Subsequently, the percentage of the area occupied by the zirconium silicate phase in the fiber contact surface and inside the base of each sample was calculated in the following method. First of all, backscattered electron image pictures of the fiber contact surface and the inside of the base were taken by using the SEM. As the zirconium silicate phase exhibits a white-based color, the image analysis was performed on the picture by applying a particle analysis technique of the image analysis software "A-zo Kun" so that the percentage of the area occupied by the zirconium silicate phase was obtained. Specifically, the percentage of the area occupied by the zirconium silicate phase in the fiber contact surface was the average value of the image analysis on two pictures at different areas in the inlet portion, the intermediate portion, and the outlet portion of the fiber contact surface captured at 2000 magnification. Conversely, the percentage of the area occupied by the zirconium silicate phase inside the base was the average value of the image analysis on six pictures at different areas of the inside captured at 2000 magnification.

[0059] The sliding test was performed in the same manner as in the first embodiment except that the start time of the measurement of a friction coefficient was 20 minutes after the start of the sliding test, and the friction coefficient of the fiber contact surface of each sample was obtained. Table 2 illustrates the results.

Table 2

SAMPLE NO.	ZIRCONIUM SILICATE POWDERS (MASS-%)		PERCENTAGE OF AREA OCCUPIED BY ZIRCONIUM SILICATE PHASE			FRICTION COEFFICIENT μ
	SLURRY	BARREL FINISHING	FIBER CONTACT SURFACE	INSIDE	DIFFERENCE (FIBER CONTACT SURFACE-INSIDE)	
3	0.2	0	0.2	0.2	0	0.4
4	0	0.01	0.13	0	0.13	0.38
5	0	0.015	0.2	0	0.2	0.36
6	0	0.04	0.6	0	0.6	0.35
7	0	0.13	1.8	0	1.8	0.34
8	0.2	0.13	2.0	0.2	1.8	0.34

[0060] According to the results illustrated in Table 2, samples No. 4 to 8 had a low friction coefficient of 0.38 or less in the fiber contact surface, as compared with the sample No. 3. This indicates that, when the percentage of the area occupied by the zirconium silicate phase in the fiber contact surface is higher than the percentage of the area occupied by the zirconium silicate phase inside the base, the friction coefficient of the fiber contact surface may be maintained.

[0061] Among the samples No. 4 to 8, the samples No. 5 to 8 had a low friction coefficient of 0.36 or less in the fiber contact surface. This indicates that, when the percentage of the area occupied by the zirconium silicate phase in the fiber contact surface is higher than the percentage of the area occupied by the zirconium silicate phase inside the base by 0.2 or more area-%, the friction coefficient of the fiber contact surface may be further maintained.

[Third Embodiment]

[0062] Then, oiling nozzles having different percentages of the area occupied by the zirconium silicate phase in the inlet portion and the intermediate portion of the fiber contact surface were produced. A sliding test was performed on the oiling nozzles to compare the friction coefficients of the fiber contact surfaces.

[0063] The production method was the same as the method for producing the sample No. 1 according to the first embodiment except that the amount of zirconium silicate powders doped and mixed with water during barrel finishing was adjusted and parts of the inlet portion and the intermediate portion in the fiber contact surface were masked so that the percentage of the area occupied by the zirconium silicate phase became the value illustrated in Table 3, and a sample No. 9 was the same sample as the sample No. 1 according to the first embodiment.

[0064] Subsequently, a sliding test was performed in the same manner as in the first embodiment to obtain the friction coefficient of the fiber contact surface of each sample. Table 3 illustrates the results.

Table 3

SAMPLE NO.	PERCENTAGE OF AREA OCCUPIED BY ZIRCONIUM SILICATE PHASE (AREA-%)		FRICTION COEFFICIENT μ
	INLET PORTION	INTERMEDIATE PORTION	
9	0.2	0.2	0.36
10	0.1	0.2	0.37
11	0.2	0.1	0.32
12	0.3	0.1	0.29
13	1	0.1	0.28
14	2.5	0.1	0.29
15	3	0.1	0.32

[0065] According to the results illustrated in Table 3, the samples No. 11 to 15 have a low friction coefficient of 0.32

or less in the fiber contact surface, as compared with the samples No. 9, 10. This indicates that, when the percentage of the area occupied by the zirconium silicate phase in the inlet portion is higher than the percentage of the area occupied by the zirconium silicate phase in the intermediate portion, the friction coefficient of the fiber contact surface may be lower.

[0066] Among the samples No.11 to 15, the samples No. 12 to 14 have a low friction coefficient of 0.29 or less in the fiber contact surface. This indicates that, when the percentage of the area occupied by the zirconium silicate phase in the inlet portion is 0.3 or more area-% and 2.5 or less area-%, the friction coefficient of the fiber contact surface may be lower.

[Fourth Embodiment]

[0067] Then, oiling nozzles having different average values of the equivalent circle diameter of the zirconium silicate phase in the fiber contact surface were produced. A sliding test was performed on the oiling nozzles to compare the friction coefficients of the fiber contact surfaces.

[0068] The production method was the same as the method for producing the sample No. 6 according to the second embodiment except that the zirconium silicate powder having the average particle diameter illustrated in Table 4 was used during barrel finishing and the barrel time period illustrated in Table 4 was applied, and a sample No. 20 was the same sample as the sample No. 6 according to the second embodiment. The barrel time period for each sample was changed so that the percentage of the area occupied by the zirconium silicate phase in the fiber contact surface of each sample became 0.6 area-%.

[0069] Subsequently, the average value of the equivalent circle diameter of the zirconium silicate phase in the fiber contact surface of each sample was calculated in the same method as the method for calculating the percentage of the area occupied by the zirconium silicate phase in the fiber contact surface according to the second embodiment.

[0070] A sliding test was performed in the same manner as in the second embodiment to obtain the friction coefficient of the fiber contact surface of each sample. Table 4 illustrates the results.

Table 4

SAMPLE NO.	AVERAGE PARTICLE DIAMETER (μm) OF ZIRCONIUM SILICATE POWDER	BARREL TIME PERIOD (HOUR)	AVERAGE VALUE (μm) OF EQUIVALENT CIRCLE DIAMETER OF ZIRCONIUM SILICATE PHASE	FRICTION COEFFICIENT μ
16	0.4	6	0.4	0.35
17	0.4	5	0.6	0.29
18	1.8	4	1.8	0.27
19	3.2	3	3.2	0.29
20	3.5	2	3.5	0.35

[0071] According to the results illustrated in Table 4, samples No. 17 to 19 have a low friction coefficient of 0.29 or less in the fiber contact surface, as compared with the samples No. 16, 20. This indicates that, when the average value of the equivalent circle diameter of the zirconium silicate phase in the fiber contact surface is 0.6 or more μm and 3.2 or less μm, the friction coefficient of the fiber contact surface may be further maintained.

Reference Signs List

[0072]

1: FIBER
2: FIBER CONTACT SURFACE
3: INLET PORTION
4: INTERMEDIATE PORTION
5: OUTLET PORTION
6: FIRST END
7: SECOND END
8: ZIRCONIUM SILICATE PHASE
9: ALUMINUM OXIDE CRYSTAL

10A: ROLLER GUIDE
10B: OILING NOZZLE
10C: ROD GUIDE
10D: TRAVERSE GUIDE
10E: FRICTION DISK
10: FIBER GUIDE
11: BASE
R1 TO R4: ROLLER

Claims

1. A fiber guide comprising:

a base; and
a fiber contact surface that is brought into contact with a fiber in at least part of the base, the fiber contact surface including an aluminum oxide ceramic and including a zirconium silicate phase between aluminum oxide crystals.

2. The fiber guide according to claim 1, wherein
the base and the fiber contact surface including an integrated aluminum oxide ceramic, and
a percentage of an area occupied by the zirconium silicate phase in the fiber contact surface is higher than a percentage of an area occupied by the zirconium silicate phase inside the base.

3. The fiber guide according to claim 2, wherein the percentage of the area occupied by the zirconium silicate phase in the fiber contact surface is higher than the percentage of the area occupied by the zirconium silicate phase inside the base by 0.2 or more area-%.

4. The fiber guide according to any one of claims 1 to 3, wherein
the fiber contact surface includes an inlet portion, an intermediate portion, and an outlet portion, and
a percentage of an area occupied by the zirconium silicate phase in the inlet portion is higher than a percentage of an area occupied by the zirconium silicate phase in the intermediate portion.

5. The fiber guide according to claim 4, wherein the percentage of the area occupied by the zirconium silicate phase in the inlet portion is 0.3 or more area-% and 2.5 or less area-%.

6. The fiber guide according to any one of claims 1 to 5, wherein an average value of an equivalent circle diameter of the zirconium silicate phase in the fiber contact surface is 0.6 or more μm and 3.2 or less μm.

FIG.1

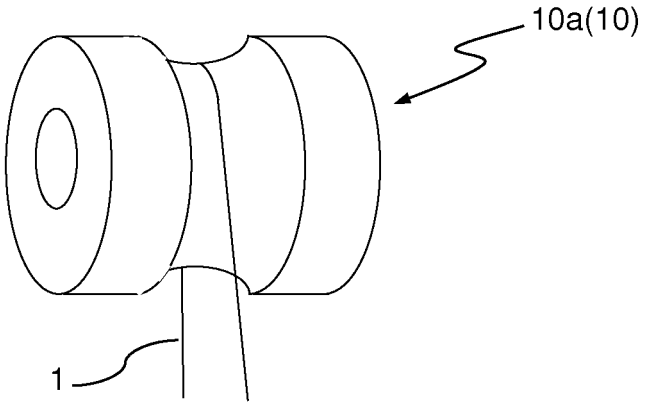


FIG.2

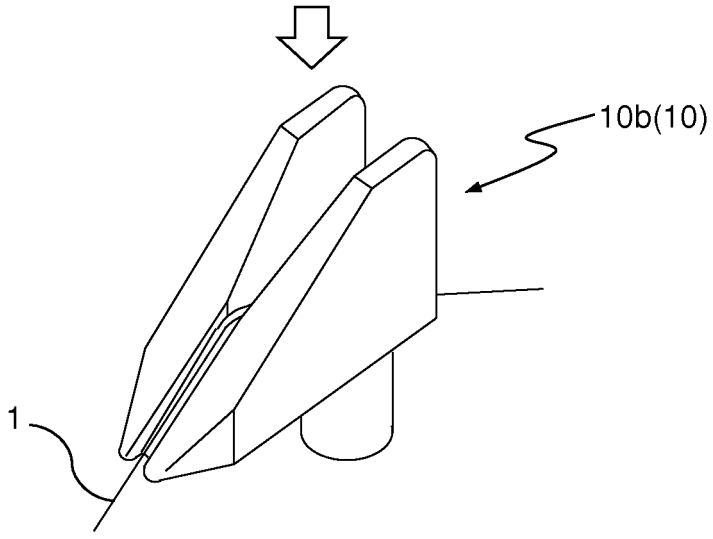


FIG.3

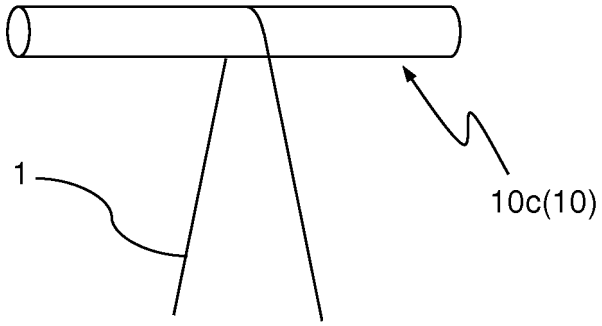


FIG.4

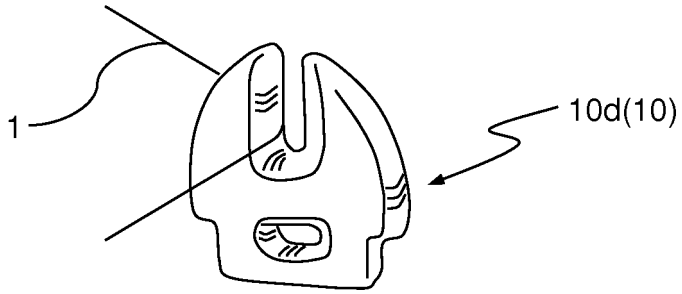


FIG.5

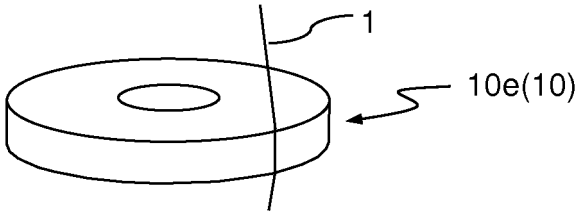


FIG.6

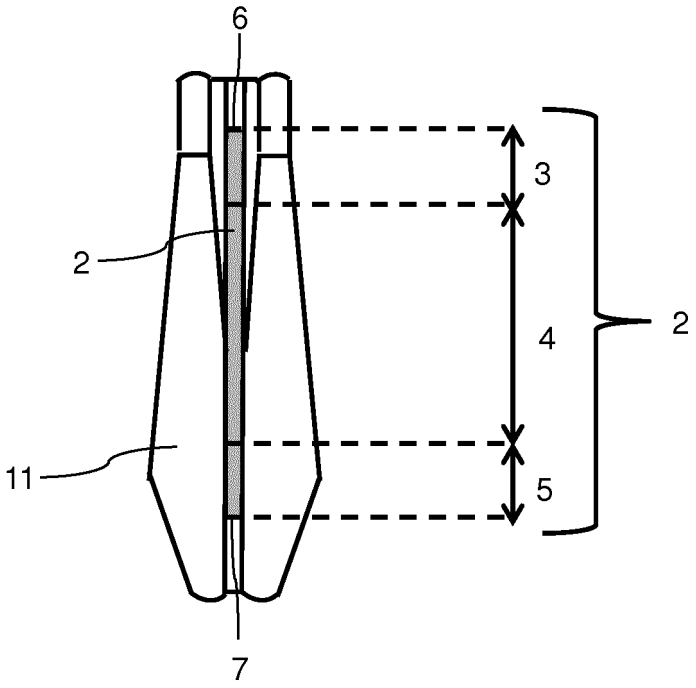


FIG.7

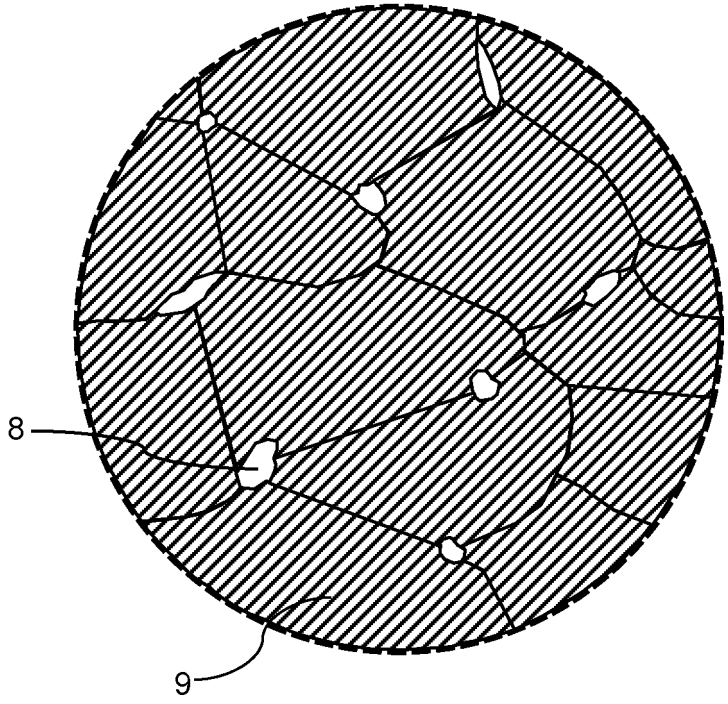
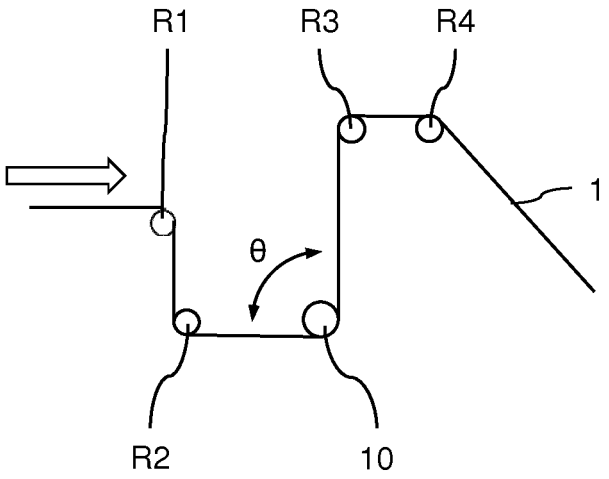


FIG.8



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2018/012082

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. D01D11/04(2006.01)i, B65H57/24(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)
Int.Cl. D01D1/00-13/02, B65H57/00-57/28

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

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2018
Registered utility model specifications of Japan	1996-2018
Published registered utility model applications of Japan	1994-2018

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Japio-GPG/FX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP 2001-158658 A (KYOCERA CORPORATION) 12 June 2001, claims, paragraphs [0011], [0015]-[0018], examples, no. 5, 7 (Family: none)	1, 6 2-5
A	WO 2016/136819 A1 (KYOCERA CORPORATION) 01 September 2016, claims, examples & EP 3248925 A1, claims, examples & CN 107250015 A	1-6

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26.04.2018	15.05.2018

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2018/012082

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 11-286824 A (TORAY INDUSTRIES) 19 October 1999, claims, examples (Family: none)	1-6
A	WO 2012/176777 A1 (KYOCERA CORPORATION) 27 December 2012, claims, examples & CN 102839438 A & CN 202809036 U	1-6

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2003213522 A **[0005]**