



US 20230027891A1

(19) **United States**

(12) **Patent Application Publication**  
**SEKIYAMA et al.**

(10) **Pub. No.: US 2023/0027891 A1**

(43) **Pub. Date: Jan. 26, 2023**

(54) **FABRIC, AND CABLE COVER FOR ROBOT ARM**

*D03D 15/41* (2006.01)

*D03D 15/513* (2006.01)

*D03D 13/00* (2006.01)

*D02G 3/04* (2006.01)

(71) Applicant: **TORAY Industries, Inc.**, Tokyo (JP)

(72) Inventors: **Masato SEKIYAMA**, Otsu-shi (JP);  
**Yuki NINOMIYA**, Otsu-shi (JP);  
**Masaru HARADA**, Otsu-shi (JP)

(52) **U.S. Cl.**

CPC ..... *D03D 15/225* (2021.01); *D03D 15/56*

(2021.01); *D03D 15/283* (2021.01); *D03D*

*15/573* (2021.01); *D03D 15/292* (2021.01);

*D03D 15/41* (2021.01); *D03D 15/513*

(2021.01); *D03D 13/004* (2013.01); *D02G*

*3/045* (2013.01); *D10B 2331/04* (2013.01);

*D10B 2321/042* (2013.01); *D10B 2331/021*

(2013.01); *D10B 2331/14* (2013.01); *D10B*

*2401/061* (2013.01); *D10B 2401/063* (2013.01)

(73) Assignee: **TORAY Industries, Inc.**, Tokyo (JP)

(21) Appl. No.: **17/783,299**

(22) PCT Filed: **Oct. 27, 2020**

(86) PCT No.: **PCT/JP2020/040195**

§ 371 (c)(1),

(2) Date: **Jun. 8, 2022**

(57)

**ABSTRACT**

For providing a fabric that has a low frictional property and can exhibit long-term tribological properties even when the fabric is subjected to a high-speed frictional force under a high load, there is provided a fabric according to the present invention is a fabric in which a composite yarn of fluoro-resin fibers A and fibers B other than fluoro-resin fibers is used for at least one of a warp yarn and a weft yarn, and the fabric is characterized in that a mass ratio  $\alpha$  of the fluoro-resin fibers A in the composite yarn is 5 to 70%, and a ratio of the area ratio X of the fluoro-resin fibers in a fabric surface to a mass ratio Y of the fluoro-resin fibers in the fabric is 1 or more and 5 or less. This fabric can be usefully used for a cable cover for a robot arm.

(30) **Foreign Application Priority Data**

Dec. 20, 2019 (JP) ..... 2019-230476

**Publication Classification**

(51) **Int. Cl.**

*D03D 15/225* (2006.01)

*D03D 15/56* (2006.01)

*D03D 15/283* (2006.01)

*D03D 15/573* (2006.01)

*D03D 15/292* (2006.01)

## FABRIC, AND CABLE COVER FOR ROBOT ARM

### TECHNICAL FIELD

**[0001]** The present invention relates to a fabric with wear resistance, and a robot arm cable cover.

### BACKGROUND ART

**[0002]** Conventionally with the use of the low friction coefficients of fluororesins, the fluororesins are formed into fibers and disposed as woven or knitted fabrics or nonwoven fabrics on the surfaces of sliding materials, thereby developing sliding fabrics with friction durability improved. Furthermore, because fluororesin fibers are typically low in strength, techniques are disclosed in which fibers with higher strength than fluororesin fibers are interweaved with fluororesin fibers to improve sliding durability. As the interweaving techniques mentioned above, techniques are disclosed, such as a double woven fabric in which fluororesin fibers are arranged on a sliding surface, whereas fibers other than fluororesin fibers are arranged on a non-sliding surface, and a fabric made from a composite yarn formed from fluororesin fibers and fibers other than fluororesin fibers.

**[0003]** For example, Patent Document 1 discloses a heat and abrasion resistant multi-layer woven fabric that is a multi-layer woven fabric including a fluororesin fiber-containing sliding woven fabric and a foundation woven fabric and that is made to have an optimal configuration on the foundation fabric to have high heat resistance and high wear resistance and be thus capable of exhibiting long-term tribological properties even when exposed to a high-temperature environment. PTFE abraded by sliding is received at entangled binding points (binding points obtained by entanglement) between the sliding woven fabric and the foundation woven fabric or on the side with the sliding surface of the foundation woven fabric, and the entangled binding points or the sliding woven fabric-side surface of the foundation woven fabric is coated with some of the PTFE, and the remaining PTFE is accumulated in dents of the foundation woven fabric, and even if the entire multi-layer woven fabric is abraded, the PTFE accumulated in the dents of the foundation woven fabric continues to coat the surface of the foundation woven fabric, thereby keeping the fabric surface continuously coated with the PTFE, and showing the effect of keeping tribological properties for a long period of time.

**[0004]** Patent Document 2 discloses a self-lubrication fabric including a composite yarn formed from fluororesin fibers and other fibers, in which a ratio of the surface area of the other fibers on one side of the fabric to the surface area of the entire composite yarn is 0 to 30%.

### PRIOR ART DOCUMENTS

#### Patent Documents

- [0005]** Patent Document 1: Japanese Patent No. 6398189  
**[0006]** Patent Document 2: WO 2017/020821 A

### SUMMARY OF THE INVENTION

#### Problems to be Solved by the Invention

**[0007]** The woven fabric described in Patent Document 1 has been a double woven fabric in which PTFE fibers and

other fibers were separately arranged respectively in a sliding fabric layer and a foundation fabric layer. Thus, there has been a problem that the fluororesin fibers are likely to be discharged when the fabric is exposed to high-speed sliding under a high load, thereby failing to achieve sufficient long-term sliding durability.

**[0008]** The self-lubrication fabric described in Patent Document 2 has the composite yarn made from the fluororesin fibers and the other fibers, thereby making a fluorine abrasion powder likely to be transferred to the other fibers adjacent to the fluororesin fibers, and improving the sliding durability under a high load. The ratio of the fluororesin fibers in the composite yarn is, however, made excessively higher than that of the other fibers for achieving a low frictional property, and thus, when the fabric is exposed to high-speed sliding under a high load, discharge of an abrasion powder from the fluororesin yarn also fails to be sufficiently suppressed, and there is room for improvement in long-term sliding durability.

**[0009]** Accordingly, an object of the present invention is to provide a fabric that has a low frictional property and can exhibit long-term tribological properties even when the fabric is subjected to a high-speed frictional force under a high load.

#### **[0010]** Solutions to the Problems

**[0011]** In order to achieve the object, the present invention has the following configurations.

**[0012]** A fabric in which a composite yarn of fluororesin fibers A and fibers B other than fluororesin fibers is used for at least one of a warp yarn and a weft yarn, a mass ratio  $\alpha$  of the fluororesin fibers A in the composite yarn is 5 to 70%, and a ratio X/Y of the area ratio X of the fluororesin fibers A in the fabric surface to a mass ratio Y of the fluororesin fibers A in the fabric is 1 or more and 5 or less.

**[0013]** The fabric in which the composite yarn is used for either the warp yarn or the weft yarn, and the fibers B are used as either the weft yarn or the warp yarn orthogonal to the composite yarn.

**[0014]** The fabric in which the area ratio X is 10% or more and 60% or less.

**[0015]** The fabric in which the composite yarn is a doubled and twisted yarn obtained by doubling and twisting the fluororesin fibers A and the fibers B other than fluororesin fiber.

**[0016]** The fabric in which the fibers B constituting the doubled and twisted yarn is a twisted yarn.

**[0017]** The fabric in which the fluororesin fibers A are made from a polytetrafluoroethylene resin.

**[0018]** The fabric in which the fibers B are fibers that are 7 cN/dtex or more in tensile strength.

**[0019]** The fabric in which the fibers B are fibers that are 15 to 50 cN/dtex in tensile strength.

**[0020]** The fabric in which the fibers B are fibers that have a heat resistance temperature of 280° C. or higher.

**[0021]** The fabric in which the fibers B are fibers that are 450 to 800 cN/dtex in tensile modulus of elasticity.

**[0022]** The fabric in which the fibers B are organic fibers.

**[0023]** The fabric in which the fibers B are fibers selected from liquid crystal polyester fibers, para-aramid fibers, and polyparaphenylene benzobisoxazole fibers.

**[0024]** A robot arm cable cover including, in at least a part thereof, the fabric.

## Effects of the Invention

[0025] According to the present invention, provided is a fabric that has a low frictional property and can exhibit long-term tribological properties even when the fabric is subjected to a high-speed frictional force under a high load.

## EMBODIMENTS OF THE INVENTION

[0026] A fabric according to the present invention is a fabric in which a composite yarn of fluoro-resin fibers A and fibers B other than fluoro-resin fibers is used for at least one of a warp yarn and a weft yarn, and the fabric is characterized in that a mass ratio  $\alpha$  of the fluoro-resin fibers A in the composite yarn is 5 to 70%, and a ratio of an area ratio X of the fluoro-resin fibers A in a fabric surface to a mass ratio Y of the fluoro-resin fibers A in the fabric is 1 or more and 5 or less. The fluoro-resin fibers is arranged in the fabric as a composite yarn with fibers other than the fluoro-resin fibers, thereby making the fluoro-resin fibers and the fibers B adjacent to each other in the fabric, and the fluorine abrasion powder generated by abrasion of the fluoro-resin fibers A due to sliding is then easily transferred to the fibers B to a self-lubrication film, thus allowing excellent abrasion durability under a high load to be achieved. Furthermore, the mass ratio of the fluoro-resin fibers in the composite yarn, the area ratio of the fluoro-resin fibers, and the mass ratio of the fluoro-resin fibers in the fabric are each optimized against high-speed sliding under a high load, thereby causing the fibers other than the fluoro-resin fibers to support the fabric as skeletal yarns, and even when the fabric is subjected to a high-speed frictional force under a high load, tribological properties can be exhibited for a long period of time.

[0027] For the fabric according to the present invention, the composite yarn of the fluoro-resin fibers A and the fibers B other than fluoro-resin fibers is used for at least one of a warp yarn and a weft yarn. More preferably, the composite yarn is used for either the warp yarn or the weft yarn, and the fibers B are used as either the weft yarn or the warp yarn orthogonal to the composite yarn. Such a configuration allows a fabric in which X/Y to be described later has an appropriate value to be more easily obtained. Furthermore, an aspect is particularly preferred in which the composite yarn is used for the warp yarn, whereas the fibers B are used for the weft yarn. In general, because the crimp of the weaving yarn is large with the warp yarn and small with the weft yarn, such a configuration makes the composite yarn including the fluoro-resin fibers A likely to be exposed at the surface of the fabric, and has the fibers B linearly arranged in the fabric, thus improving the strength utilization efficiency of the fibers B. It is to be noted that when the crimp of the weft yarn is larger than the crimp of the warp yarn, it is also preferable to use the fiber B for the warp yarn and the composite yarn for the weft yarn. In the case of using the composite yarn for either the warp yarn or the weft yarn, the weft yarn or the warp yarn orthogonal to the composite yarn preferably has the same type of fiber as the fibers B. "The same type of fiber" as used herein means a fiber made of the same polymer, and need not have the same number of filaments or the same fineness. It is to be noted that "the same polymer" as used herein may be any polymer as long as the polymer constituting the fiber is substantially the same polymer, and may differ in the presence or absence of and types of additives added. In addition, "substantially the same" does not require strictly the same, and may be a

polymer such as a combination of a homopolymer and a copolymer or a combination of a copolymer and another copolymer, as long as with a common main repeating unit, wrinkle generation and anisotropy of sliding durability described later are not significantly impaired in the fabric obtained. The same type of the fiber as the fibers B used for the composite yarn is used as the weft yarn or the warp orthogonal to the composite yarn, thereby allowing for suppressing the generation of wrinkles due to a difference in thermal shrinkage between the warp yarn and the weft yarn, and for reducing anisotropy of sliding durability due to a difference in yarn strength.

[0028] The mass ratio  $\alpha$  of the fluoro-resin fibers A in the composite yarn is 5 to 70%. The mass ratio  $\alpha$  of the fluoro-resin fibers A in the composite yarn between the values mentioned above allows the low frictional property, and the transfer of the fluorine abrasion powder to the fibers B, and the strength of the fibers B as an aggregate to be each achieved in optimum balance. The mass ratio  $\alpha$  is more preferably 25 to 60%, and particularly preferably 40 to 55% from the viewpoint of balance between strength and tribological properties. When the mass ratio  $\alpha$  of the fluoro-resin fibers A in the composite yarn is less than 5%, the low frictional property will be significantly impaired. When the mass ratio  $\alpha$  is more than 70%, the fluoro-resin fibers and the fluorine abrasion powder will be significantly fractured and discharged respectively, thereby failing to achieve desired durability.

[0029] The means for obtaining the composite yarn from the fluoro-resin fibers A and the fibers B is not to be considered particularly limited, and can be selected from means such as doubling and twisting, combining filament yarn, and blending spun yarn. The use of doubling and twisting, and combining filament yarn is preferred, because of allowing filament yarns to be selected as the fluoro-resin fibers A and the fibers B, and thus increasing the strength of the composite yarn. The use of combining filament yarn allows the single yarns of the fluoro-resin fibers A and fibers B constituting the composite yarn to be more uniformly combined, thus allowing for obtaining a composite yarn that is uniform in the cross-sectional direction. The use of doubling and twisting allows a composite yarn to be obtained without being entangled, thus allowing for obtaining a composite yarn that is uniform in the longitudinal direction.

[0030] In the case of obtaining a composite yarn by doubling and twisting the fluoro-resin fibers A and the fibers B, the number of twists at the time of the doubling and twisting preferably has a twist coefficient k of 1000 or more and 25000 or less. In this regard, the twist coefficient k is determined by the following formula where the number of twists per 1 m is denoted by T [t/m], with the fineness D [dtex] of the composite yarn.

$$k = T \times D^{0.5}$$

The twist coefficient k is more preferably 1000 or more and 10,000 or less, particularly preferably 2000 or more and 7000 or less.

[0031] In the case of obtaining a composite yarn by doubling and twisting the fluoro-resin fibers A and the fibers B, the fibers B before doubling and twisting are preferably subjected to yarn twisting. Because the opening of the fibers B due to abrasion during weaving can be suppressed by the yarn twisting, a phenomenon can be thus prevented in which

the fibers B opened cover the fluoro-resin fibers A in the composite yarn, thereby disturbing the low frictional property. In this case, the twist coefficient of the fibers B before the doubling and twisting is preferably 500 or more and 5000 or less. Furthermore, when the twist coefficient is 500 or more and 3000 or less, in addition to the effect mentioned above, the yarn twisting improves the strength of the fibers B to make the fibers B more firmly present as skeletal yarns in the case of a fabric provided, thus improving the sliding durability. The twist coefficient is particularly preferably 900 or more and 3000 or less. If the twist coefficient of the fibers B is more than 5000, the strength may be lower than that before the yarn twisting. For the fibers B subjected to yarn twisting, a step of simply applying twists to the original yarn with a desired fineness may be employed, or a step of twisting together yarns with a fineness smaller than a desired fineness may be employed. For example, in preparing fibers B of 33 [t/m] in the number of twists and 850 [dtex] in fineness, an original yarn for the fibers B with a fineness of 850 [dtex] may be subjected to yarn twisting for 33 [t/m], or two original yarns for the fibers B with a fineness of 425 [dtex] may be subjected to doubling and twisting for 33 [t/m].

**[0032]** For the fabric according to the present invention, the ratio X/Y of the area ratio X of the fluoro-resin fibers A to the fabric surface to the mass ratio Y of the fluoro-resin fibers A in the fabric is 1 or more and 5 or less. "The area ratio of the fluoro-resin fibers A to the fabric surface" as used herein means the ratio of an area  $S_A$  occupied by the fluoro-resin fibers A to an imaged area  $S_{tot}$  obtained by imaging a surface of the fabric with a microscope, and the area ratio is obtained by the formula below.

$$\text{Area Ratio } X \text{ of Fluoro-resin Fiber } A = S_A/S_{tot} \times 100[\%]$$

**[0033]** X/Y represents the degree of distribution at the fabric surface, of the fluoro-resin fibers A present in the fabric, which means that the fluoro-resin fibers are concentrated more at the fabric surface as X/Y is larger. In order to obtain excellent abrasion durability, a balance is important between the low frictional property in an initial stage of sliding and the low frictional property in the case of the fabric abrasion advanced by sliding, and X/Y is more preferably 1 to 2, still more preferably 1.2 to 1.65. In particular, in the case of 1.2 to 1.6, particularly excellent sliding durability can be obtained while initial tribological properties are obtained, and the case can be mentioned as a particularly preferred condition. When X/Y is smaller than 1, the fluoro-resin fibers A present at the fabric surface are reduced with respect to the mass ratio of the fluoro-resin fibers A in the fabric. For this reason, when the fabric is exposed to high-speed sliding under a high load, the frictional resistance force with respect to the fabric strength is relatively high in an initial stage of sliding, the origin of a fracture is likely to be produced early, and insufficient abrasion durability can be obtained. As X/Y is larger, the fluoro-resin fibers A present at the fabric surface increase with respect to the mass ratio of the fluoro-resin fibers A in the fabric, the fluoro-resin fibers A present at the fabric surface excessively increase when X/Y is larger than 5, and thus when the fabric is exposed to high-speed sliding under a high load, the frictional resistance force can be reduced in an initial stage of sliding, but the fluorine abrasion powder generated by abrasion of the fluoro-resin fibers is discharged early, thereby depleting the fluoro-resin fibers remaining in

the fabric, and the frictional resistance force with respect to the fabric strength is thus relatively increased in the middle to late stage of sliding, thereby failing to obtain sufficient abrasion durability.

**[0034]** The area ratio X of the fluoro-resin fibers A to the fabric surface is preferably 10% or more and 60% or less. When the area ratio X of the fluoro-resin fibers A to the fabric surface is 10% or more, the frictional resistance force in an initial stage of sliding can be reduced to a certain extent, and abrasion durability can be secured. When the area ratio X of the fluoro-resin fibers A to the woven fabric surface is 60% or less, the fibers other than the fluoro-resin fibers can be present as skeletal yarns to a certain extent in the fabric, abrasion durability can be thus secured. From the viewpoint of reducing the frictional resistance force in an initial stage of sliding and arranging the skeletal yarns for the fabric, the area ratio X is more preferably 20% or more and 55% or less, and can be 40% or more and 55% or less as a particularly preferred condition.

**[0035]** The mass ratio Y of the fluoro-resin fibers in the fabric is preferably 5% or more and 55% or less. More preferably, the mass ratio Y is 15% or more and 55% or less, and can be 25% or more and 45% or less as a particularly preferred condition.

**[0036]** In order for X/Y to meet the range mentioned above, more fluoro-resin fibers are preferably arranged at the fabric surface. More specifically, in order for X/Y to fall within the range mentioned above, many fluoro-resin fibers may be arranged in the vicinity of the surface layer of the composite yarn in providing the composite yarn, or the weave structure or the like may be controlled to expose many fluoro-resin fibers at the fabric surface.

**[0037]** In accordance with the present invention, the means for obtaining the composite yarn is not to be considered particularly limited, but in order to arrange many fluoro-resin fibers in the vicinity of the surface layer of the composite yarn in providing the composite yarn, can be carried out in a relatively simple manner by particularly employing the processing of doubling and twisting and controlling the conditions for the doubling and twisting. Specifically, methods can be employed, such as a method of covering the fibers B with the fluoro-resin fibers A, a method of doubling and twisting the fluoro-resin fiber A again into the doubled and twisted yarn of the fibers B and fluoro-resin fibers A, and a method of applying a high tension to the fibers B at the time of doubling and twisting to arrange the fluoro-resin fibers A on the sheath side in the composite yarn. In the case of obtaining a composite yarn by doubling and twisting the fluoro-resin fibers A and the fibers B without using the special means mentioned above, the volume ratio and area ratio of the fluoro-resin fibers A in the composite yarn almost coincide with each other. When the area ratio of the fluoro-resin fibers in the composite yarn is increased, the mass ratio Y of the fluoro-resin fibers A in the fabric is also increased, and thus, in order to control X/Y within the range of 1 or more and 5 or less, another means such as controlling the weave structure is typically used.

**[0038]** In accordance with the present invention, the weave structure is not to be considered particularly limited, but examples of means for controlling the weave structure to expose many fluoro-resin fibers at the fabric surface include a method of employing a structure such as a 3/1 twill structure, a 2/1 twill structure, or a satin structure, and changing the ratios of the warp yarn and weft yarn exposed

at the surface. X/Y can be controlled in the range of 1 or more and 5 or less by arranging yarns including more fluoro resin fibers A for the warp yarn or weft yarn exposed more at the surface. In the case of a structure such as a 2/2 twill structure and a simple plain structure, the warp yarn and the weft yarn are exposed at the surface to the same extent, thus making it difficult to expose more fluoro resin fibers at the fabric surface when a typical composite yarn is used.

**[0039]** In the present invention, the fluoro resin that is a component of the fluoro resin fibers should be configured to include a monomer unit containing one or more fluorine atoms in a main chain or a side chain. Particularly, the fluoro resin configured to include a monomer unit having many fluorine atoms is preferable.

**[0040]** The fluoro resin includes preferably 70 mol % or more, more preferably 90 mol % or more, further preferably 95 mol % or more of the monomer unit containing one or more fluorine atoms in a repeating structural unit of the polymer.

**[0041]** Examples of the monomer containing one or more fluorine atoms include fluorine atom-containing vinyl-based monomers such as tetrafluoroethylene, hexafluoropropylene, and chlorotrifluoroethylene, and particularly, use of at least tetrafluoroethylene is preferable.

**[0042]** As the fluoro resin, there can be used singly or in a blend of two or more of, for example, polytetrafluoroethylene (PTFE), a tetrafluoroethylene-hexafluoropropylene copolymer (FEP), a tetrafluoroethylene-p-fluoroalkyl vinyl ether copolymer (PFA), polychlorotrifluoroethylene (PCTFE), and an ethylene-tetrafluoroethylene copolymer (ETFE).

**[0043]** The fluoro resin including a tetrafluoroethylene unit preferably has a larger content of the tetrafluoroethylene unit in terms of sliding characteristics and is preferably a copolymer containing, of the total, 90 mol % or more, preferably 95 mol % or more of tetrafluoroethylene, and use of polytetrafluoroethylene fibers as a homopolymer of tetrafluoroethylene is most preferable.

**[0044]** As the form of the fluoro resin fibers A used in the present invention, both a monofilament formed of one filament and a multifilament formed of a plurality of filaments can be used, but a multifilament is preferable from the viewpoint of the weaving performance and the roughness on the surface of the fabric into which the fibers are formed.

**[0045]** The fluoro resin fibers A used in the present invention preferably have a total fineness in the range of 50 to 6000 dtex. The total fineness more preferably falls within the range of 500 to 5500 dtex, still more preferably within the range of 400 to 1500 dtex. When the total fineness of the fibers constituting the fabric is 50 dtex or more, the strength of the fibers can be secured to a certain extent, breakages of yarns during weaving can be also reduced, and the process passing property can be thus improved. When the total fineness is 6000 dtex or less, favorable processability during weaving is obtained.

**[0046]** As the fibers B, organic fibers such as cotton, polyester fibers, polyamide fibers, polyparaphenylene terephthalamide (para-aramid) fibers, polymethaphenylene isophthalamide (meta-aramid) fibers, polyphenylene sulfide (PPS) fibers, polyparaphenylene benzobisoxazole (PBO) fibers, ultra-high molecular weight polyethylene (UHMWPE) fibers, and liquid crystal polyester fibers, and inorganic fibers such as glass fibers, carbon fibers, and

silicon carbide fibers can be used, and from the viewpoint of processability, organic fibers are preferred.

**[0047]** From the viewpoint of improving the abrasion durability of the fabric, the fibers B are preferably fibers that are 7 cN/dtex or more in tensile strength. The fibers B are more preferably 15 to 50 cN/dtex in tensile strength, further preferably 18 to 50 cN/dtex in tensile strength. The fibers B with such a tensile strength allows fiber fractures to be further suppressed even when the fabric is subjected to high-speed sliding under a high load, and allows for helping the formation of a self-lubrication film by abrasion of the fluoro resin fibers.

**[0048]** From the viewpoint of durability in an environment where frictional heat is generated by sliding, the fibers B are preferably fibers that have a heat resistance temperature of 280° C. or higher. The heat resistance temperature as used herein means that the melting point, the softening point, or the decomposition point is equal to or higher than the temperature. It is to be noted that in the case where the fibers B have two or more of the melting point, softening point, and decomposition point, the point at a lower temperature is to be employed. The heat resistance temperature of the fibers is more preferably 300° C. or higher, and furthermore, the fibers without any melting point allows softening due to frictional heat to be suppressed, and allows excellent abrasion durability to be obtained.

**[0049]** From the viewpoint of dimensional stability of the fabric, the fibers B are preferably fibers that are 20 to 800 cN/dtex in tensile modulus of elasticity. Further, the fibers B with a tensile modulus of elasticity in the range of 450 to 800 cN/dtex enables the fabric to maintain the structure thereof even when the fabric is subjected to high-speed sliding under a high load, and thus to obtain especially excellent wear resistance. The fibers B having a tensile modulus of elasticity of 20 cN/dtex or more improve the dimensional stability of the fabric and give the fabric having excellent wear resistance. The fibers B having a tensile modulus of elasticity of 800 cN/dtex or less are preferable because they are not excessively high in stiffness and never impair the weaving performance even when interwoven with the fluoro resin fibers having a low stiffness. The fibers B preferably have an elongation of 1 to 15%, further preferably in the range of 1 to 5%. The fibers B having an elongation of particularly 1 to 3% can reduce the dimensional change of the fabric subjected to the frictional force, and therefore such an elongation can be listed as an especially preferable condition. The fibers B having an elongation of 1% or more can reduce yarn breakage during weaving to improve the process passability. The fibers B having an elongation in the range of 1 to 15% allow the fabric to improve the dimensional stability and to be applicable to a part requiring dimensional accuracy as a sliding fabric.

**[0050]** In view of the foregoing, the fibers B are particularly preferably fibers selected from liquid crystal polyester fibers, para-aramid fibers, and polyparaphenylene benzobisoxazole fibers.

**[0051]** The form of the fibers B is not especially limited, and either of a filament (long fiber) and a spun yarn may be employed, but the fibers B are preferably filaments from the viewpoint of tensile strength and tensile stiffness. Furthermore, both a monofilament formed of one filament and a multifilament formed of a plurality of filaments can be used, but the multifilament is particularly preferred because the multifilament has a large surface area, and thus facilitates the

transfer, to the fibers B, of the fluorine abrasion powder generated by abrasion of the fluoro-resin fibers A.

**[0052]** The fibers B preferably have a total fineness in the range of 200 to 4000 dtex. The total fineness is more preferably in the range of 4000 to 4000 dtex, and further in the range of 800 to 2000 dtex. When having a total fineness of 200 dtex or more, the fibers constituting the fabric are strong, and can suppress fiber fractures at the time of abrasion and also reduce yarn breakage during weaving to improve the process passability. The fibers having a total fineness of 4000 dtex or less enables the fabric to have small roughness on the surface thereof and to reduce the influence on the low frictional property.

**[0053]** In order to further increase the wear resistance of the fabric configured as above, it is possible to use the fabric that has been impregnated with a resin. Here, as the resin used for resin impregnation, thermosetting resin or thermoplastic resin can be used. The resin is not especially limited, and as the thermosetting resin, there can be preferably used, for example, phenolic resins, melamine resins, urea resins, unsaturated polyester resins, epoxy resins, polyurethane resins, diallyl phthalate resins, silicon resins, polyimide resins, vinyl ester resins, and modified resins thereof, and as the thermoplastic resin, there can be preferably used, for example, vinyl chloride resins, polystyrene resins, ABS resins, polyethylene resins, polypropylene resins, fluoro-resins, polyamide resins, polyacetal resins, polycarbonate resins, and polyester resins, and further there can be preferably used, for example, synthetic rubbers or elastomers such as thermoplastic polyurethane, butadiene rubbers, nitrile rubbers, neoprene, and polyester elastomers. Particularly, there can be preferably used resin containing phenolic resin and polyvinyl butyral resin as main components, unsaturated polyester resin, vinyl ester resin, polyolefin-based resin such as polyethylene and polypropylene, and polyester resin, in terms of the impact resistance, the dimensional stability, the strength, the costs, and the like. These types of thermosetting resin and thermoplastic resin may contain various additive agents that are usually used for the industrial purpose or application, the productivity in the manufacturing process or processing, or the improvement of the characteristics. The resin can contain, for example, a modifier, a plasticizer, a filler, a mold lubricant, a colorant, a diluent, or the like. "The main component" as used herein means a component having the largest mass ratio among components except a solvent, and the resin containing phenolic resin and polyvinyl butyral resin as the main components means that these two types of resin have the first largest and second largest (no particular order) mass ratios.

**[0054]** As the method for impregnating the fabric with resin, when a thermosetting resin is used, a method is generally used in which the thermosetting resin is dissolved in a solvent to be adjusted into varnish and the varnish is impregnated into a fabric for coating by knife coating, roll coating, comma coating, gravure coating, or the like. Alternatively, when the thermoplastic resin is used, melt extrusion lamination or the like is generally used.

**[0055]** A lubricant or the like can also be added to the fabric according to the present invention as necessary. The type of the lubricant is not especially limited, but is preferably a silicon-based lubricant or a fluorine-based lubricant material.

**[0056]** The thus obtained fabric according to the present invention is a doubled and twisted yarn fabric obtained by

optimizing the configuration of the fluoro-resin fibers A and the fibers B other than fluoro-resin fibers, and thus, even when the fabric is subjected to high-speed sliding under a high load, the discharge of fluorine abrasion powder is suppressed, and the fibers B function as skeletal yarns that support the fluoro-resin fibers A, thereby providing long-term sliding durability. Thus, the fabric according to the present invention can exhibit high sliding durability in applications that conventionally have difficulty with use for a long period of time due to high-speed sliding under a high load, and can achieve the industrially extremely high practical use. Accordingly, the fabric exhibits high durability for applications such as sliding fabrics that require tribological properties. Particularly, the fabric is preferably used for a robot arm cable covers. A robot arm cable cover including, in at least a part thereof, the fabric according to the present invention, has the low frictional property and the strength of the fabric, and thus exhibits a long-term product life even in such a use environment where the cable cover is rubbed against a part of the apparatus at a high speed under a high load.

#### EXAMPLES

**[0057]** Hereinafter, examples of the present invention will be described together with comparative examples.

**[0058]** Methods of measuring various characteristics in the present embodiment are as follows.

**[0059]** (1) Fineness

**[0060]** The fabric was disaggregated, and the fineness of the disaggregated yarn was measured in accordance with the 8.3.B method (simplified method) of JIS L1013: 2010 "Testing methods for man-made filament yarns". If the disaggregated yarn fails to secure the amount of yarn required for the measurement method mentioned above, however, the result of carrying out the test with the maximum length that can be secured and the number of trials is used as a substitute.

**[0061]** (2) Tensile Strength of Fiber

**[0062]** The fabric was disaggregated, and the fracture strength of the disaggregated yarn was measured in accordance with 8.5 of JIS L1013: 2010 "Testing methods for man-made filament yarns". If the disaggregated yarn fails to secure the amount of yarn required for the measurement method mentioned above, however, the result of carrying out the test with the maximum length that can be secured and the number of trials is used as a substitute.

**[0063]** (3) Elongation of Fiber

**[0064]** The fabric was disaggregated, and the elongation (elongation percentage) of the disaggregated yarn was measured in accordance with 8.5 of JIS L1013: 2010 "Testing methods for man-made filament yarns". If the disaggregated yarn fails to secure the amount of yarn required for the measurement method mentioned above, however, the result of carrying out the test with the maximum length that can be secured and the number of trials is used as a substitute.

**[0065]** (4) Tensile Modulus of Elasticity

**[0066]** In the measurement (3), the tensile modulus of elasticity was calculated from the elastic modulus at the elongation of 0.5% (average slope from the elongation of 0.45% to the elongation of 0.55%).

**[0067]** (5) Mass Ratio  $\alpha$  of Fluoro-resin Fibers a in Composite Yarn

**[0068]** The fabric was cut into a size of 200 mm×200 mm, and the warp yarn and the weft yarn were then disaggregated

to obtain disaggregated yarns. For each of the disaggregated warp yarns and the disaggregated weft yarns, five composite yarns were randomly selected from the disaggregated yarns obtained, and disaggregated into fluoro-resin fibers A and the other fibers, and the mass of each was measured. The mass ratio  $\alpha$  of the fluoro-resin fibers A in the composite yarn was calculated from the following calculation formula with W for the mass sum of the five composite yarns and  $W_F$  for the mass sum of the fluoro-resin fibers A of the five composite yarns.

$$\alpha = W_F / W \times 100 [\%]$$

**[0069]** If the disaggregated yarn fails to secure the amount of yarn required for the measurement method mentioned above, however, the result of carrying out the test with the maximum length that can be secured and the number of trials is used as a substitute.

**[0070]** (6) Weave Density

**[0071]** In accordance with 8.6.1 of JIS L1096: 2010 "Testing methods for woven and knitted fabrics", a sample was placed on a flat table with unnatural creases and tension removed, the number of warp yarns and weft yarns was counted in a 50-mm space at different locations, and the average values of the warp yarns and the weft yarns were calculated per unit length.

**[0072]** (7) Area Ratio X of Fluoro-resin Fibers A in Fabric Surface

**[0073]** The fabric was imaged at a magnification of 50 times with a microscope "VHX-2000" manufactured by KEYENCE CORPORATION, and the area ratio of the fluoro-resin fibers A was calculated from the calculation formula below, with the imaged area defined as  $S_{tot}$  and the area occupied by the fluoro-resin fibers A in the imaged area as  $S_A$ . If X differs between the front surface and the back surface, however, the larger value of X is employed as a representative value.

$$\text{Area Ratio X of Fluoro-resin Fiber A} = S_A / S_{tot} \times 100 [\%]$$

**[0074]** The imaged area  $S_{tot}$  and the area  $S_A$  occupied by the fluoro-resin fibers A were calculated with the use of image analyzing software "WinROOF2015" manufactured by MITANI CORPORATION.

**[0075]** (8) Mass Ratio Y of Fluoro-resin Fibers a in Fabric

**[0076]** The fabric was cut into a size of 200 mm×200 mm, the warp yarn and the weft yarn were then disaggregated, the total mass W of the disaggregated yarns was measured. Subsequently, only composite yarns were selected from the disaggregated yarns, and the total mass  $W_1$  of the composite yarns in the fabric was measured. Subsequently, fluoro-resin fibers present independently in the fabric, not as any composite yarn, were sorted out, and the total mass  $W_2$  thereof was measured. The mass ratio Y of the fluoro-resin fibers A in the fabric was calculated from the following formula.

$$Y = (W_1 \times \alpha / 100 + W_2) / W \times 100 [\%]$$

If the disaggregated yarn fails to secure the amount of yarn required for the measurement method mentioned above, however, the result of carrying out the test with the maximum length that can be secured and the number of trials is used as a substitute.

**[0077]** (9) Number of Twists

**[0078]** The fabric was disaggregated, and the number of twists of the disaggregated yarn was measured in accordance with 8.13. 1 of JIS L 1013: 2010 "Testing methods for man-made filament yarns".

**[0079]** If the disaggregated yarn fails to secure the amount of yarn required for the measurement method mentioned above, however, the result of the test carried out with the maximum length that can be secured and the number of trials can be used as a substitute.

**[0080]** (10) Kinetic Friction Coefficient

**[0081]** The kinetic friction coefficient was measured by the ring abrasion test indicated below.

**[0082]** In accordance with the Method A of JIS K7218: 1986 "Testing methods for sliding wear resistance of plastics", the woven fabrics were sampled with a length of 30 mm and a width of 30 mm, placed on a thick SUS plate with the same size about 3-mm, and fixed to a sample holder.

**[0083]** The mating material used is made of S45C, and has a hollow cylindrical ring shape of 25.6 mm in outer diameter, 20 mm in inner diameter and 15 mm in length. The surface of the ring was polished with a sandpaper to the adjusted surface roughness of  $Ra = 0.8 \mu\text{m} \pm 0.1$ . For the measurement of the roughness, a roughness tester ("SJ-201" from Mitutoyo Corporation) was used.

**[0084]** With the use of, as a ring abrasion tester, "MODEL: EFM-III-EN" manufactured by A & D Company, Limited, a test was performed at a friction load of 20 MPa and a friction speed of 400 mm/second to measure the sliding torque, and the average value was calculated from friction coefficients to fractures. Because the static friction coefficient was included immediately after the start of sliding, the average value for the friction coefficients from 1 second after the start of sliding (sliding distance: 0.4 m) to fractures was calculated as a kinetic friction coefficient.

**[0085]** The kinetic friction coefficient of smaller than 0.055 was regarded as A, the kinetic friction coefficient of 0.055 or more and 0.060 or less was regarded as B, the kinetic friction coefficient of larger than 0.060 and 0.065 or less was regarded as C, and the kinetic friction coefficient of larger than 0.065 was regarded as D.

**[0086]** (11) Sliding Durability Distance

**[0087]** In the ring abrasion test mentioned above, the sliding was continued until the fabric was fractured, and the fabric that was not fractured even after sliding of 60 m was regarded as A, the fabric fractured at 50 m or more and less than 60 m was regarded as B, the fabric fractured at 40 m or more and less than 50 m was regarded as C, the fabric fractured at 25 m or more and less than 40 m was regarded as D, and the fabric fractured at a sliding distance of less than 25 m was regarded as E.

#### Example 1

**[0088]** A PTFE fiber ("TOYOFLON" (registered trademark) from Toray Industries, Inc.) of 880 dtex in total fineness, 120 filaments in number of single yarns, and 33 t/m in number of twists and a liquid crystal polyester fiber ("SIVERAS" (registered trademark) from Toray Industries, Inc.) of 850 dtex in total fineness, 144 filaments in number of single yarns, and 33 t/m in number of twists were doubled and twisted for 167 t/m in number of twists to obtain a composite yarn as a doubled and twisted yarn, and a 3/1 twill fabric was produced by a loom with the use of the doubled and twisted yarn as the warp yarn, and a liquid crystal polyester fiber of 1700 dtex in total fineness and 288 filaments in number of single yarns ("SIVERAS" (registered trademark) from Toray Industries, Inc.) as the weft yarn. Thereafter, the fabric was refined in a refining tank at 80° C. and thermally set at 180° C.

## Example 2

**[0089]** A fabric was obtained in accordance with the same procedure as in Example 1 except that the composite yarn used in Example 1 was used for the warp yarn and the weft yarn.

## Comparative Example 1

**[0090]** A fabric was obtained in accordance with the same procedure as in Example 1 except that a PTFE fiber (“TOYOFLON” (registered trademark) from Toray Industries, Inc.) of 1760 dtex in total fineness and 240 filaments in number of single yarns was used as the weft yarn.

## Example 3

**[0091]** After doubling and twisting a liquid crystal polyester fiber (“SIVERAS” (registered trademark) from Toray Industries, Inc.) of 425 dtex in total fineness and 72 filaments in number of single yarns and a PTFE fiber (“TOYOFLON” (registered trademark) from Toray Industries, Inc.) of 880 dtex in total fineness and 120 filaments in number of single yarns, the liquid crystal polyester fiber of 425 dtex in total fineness and 72 filaments in number of single yarns was further doubled and twisted into the doubled and twisted yarn for 167 t/m in number of twists to obtain a doubled and twisted yarn. A 3/1 twill fabric was produced by a loom with the use of the doubled and twisted yarn as the warp yarn, and a liquid crystal polyester fiber of 1700 dtex in total fineness and 288 filaments in number of single yarns (“SIVERAS” (registered trademark) from Toray Industries, Inc.) as the weft yarn. Thereafter, the fabric was refined in a refining tank at 80° C. and thermally set at 180° C.

## Example 4

**[0092]** After doubling and twisting a liquid crystal polyester fiber of 850 dtex in total fineness and 144 filaments in number of single yarns (“SIVERAS” (registered trademark) from Toray Industries, Inc.) and a PTFE fiber (“TOYOFLON” (registered trademark) from Toray Industries, Inc.) of 440 dtex in total fineness and 60 filaments in number of single yarns, the PTFE fiber (“TOYOFLON” (registered trademark) from Toray Industries, Inc.) of 440 dtex in total fineness and 60 filaments in number of single yarns was further doubled and twisted into the doubled and twisted yarn for 167 t/m in number of twists to obtain a doubled and twisted yarn. A 3/1 twill fabric was produced by a loom with the use of the doubled and twisted yarn as the warp yarn, and a liquid crystal polyester fiber of 1700 dtex in total fineness and 288 filaments in number of single yarns (“SIVERAS” (registered trademark) from Toray Industries, Inc.) as the weft yarn. Thereafter, the fabric was refined in a refining tank at 80° C. and thermally set at 180° C.

## Example 5

**[0093]** A fabric was obtained in accordance with the same procedure as in Example 1 except that the fiber B before doubling and twisting was 0 t/m in number of twists.

## Example 6

**[0094]** A PTFE fiber (“TOYOFLON” (registered trademark) from Toray Industries, Inc.) of 440 dtex in total fineness, 60 filaments in number of single yarns, and 33 t/m in number of twists and a liquid crystal polyester fiber

(“SIVERAS” (registered trademark) from Toray Industries, Inc.) of 1275 dtex in total fineness, 216 filaments in number of single yarns, and 33 t/m in number of twists were doubled and twisted for 167 t/m in number of twists to obtain a doubled and twisted yarn, and a 3/1 twill fabric was produced by a loom with the use of the doubled and twisted yarn as the warp yarn, and a liquid crystal polyester fiber of 1700 dtex in total fineness and 288 filaments in number of single yarns (“SIVERAS” (registered trademark) from Toray Industries, Inc.) as the weft yarn. Thereafter, the fabric was refined in a refining tank at 80° C. and thermally set at 180° C.

## Example 7

**[0095]** A fabric was obtained in accordance with the same procedure as in Example 6 except that the composite yarn used in Example 6 was used for the warp yarn and the weft yarn.

## Comparative Example 2

**[0096]** A fabric was obtained in accordance with the same procedure as in Example 6 except that the warp yarn used in Example 6 was used for the weft yarn, whereas the weft yarn used in Example 6 was used for the warp yarn.

## Example 8

**[0097]** A PTFE fiber (“TOYOFLON” (registered trademark) from Toray Industries, Inc.) of 880 dtex in total fineness, 120 filaments in number of single yarns, and 33 t/m in number of twists and a polyparaphenylene terephthalamide fiber of 850 dtex in total fineness, 144 filaments in number of single yarns, and 33 t/m in number of twists (“KEVLAR” (registered trademark) from DU PONT-TORAY CO., LTD.) were doubled and twisted for 167 t/m in number of twists to obtain a doubled and twisted yarn, and a 3/1 twill fabric was produced by a loom with the use of the doubled and twisted yarn as the warp yarn, and a polyparaphenylene terephthalamide fiber of 1700 dtex in total fineness and 288 filaments in number of single yarns (“KEVLAR” (registered trademark) from DU PONT-TORAY CO., LTD.) as the weft yarn. Thereafter, the fabric was refined in a refining tank at 80° C. and thermally set at 180° C.

## Example 9

**[0098]** A PTFE fiber (“TOYOFLON” (registered trademark) from Toray Industries, Inc.) of 880 dtex in total fineness, 120 filaments in number of single yarns, and 33 t/m in number of twists and a polyester fiber (“TETORON”, polyethylene terephthalate fiber from Toray Industries, Inc.) of 850 dtex in total fineness, 144 filaments in number of single yarns, and 33 t/m in number of twists were doubled and twisted for 167 t/m in number of twists to obtain a doubled and twisted yarn, and a 3/1 twill fabric was produced by a loom with the use of the doubled and twisted yarn as the warp yarn, and a polyester fiber of 1700 dtex in total fineness and 288 filaments in number of single yarns (“TETORON”, polyethylene terephthalate fiber from Toray Industries, Inc.) as the weft yarn. Thereafter, the fabric was refined in a refining tank at 80° C. and thermally set at 180° C.

Example 10

[0099] A PTFE fiber (“TOYOFLON” (registered trademark) from Toray Industries, Inc.) of 880 dtex in total fineness, 120 filaments in number of single yarns, and 33 t/m in number of twists and a polyphenylene sulfide fiber (“TORCON” (registered trademark) from Toray Industries, Inc.) of 850 dtex in total fineness, 144 filaments in number of single yarns, and 33 t/m in number of twists were doubled and twisted for 167 t/m in number of twists to obtain a doubled and twisted yarn, and a 3/1 twill fabric was produced by a loom with the use of the doubled and twisted yarn as the warp yarn, and a polyphenylene sulfide fiber (“TORCON” (registered trademark) from Toray Industries, Inc.) of 1700 dtex in total fineness and 288 filaments in number of single yarns as the weft yarn. Thereafter, the fabric was refined in a refining tank at 80° C. and thermally set at 180° C.

Comparative Example 3

[0100] A PTFE fiber (“TOYOFLON” (registered trademark) from Toray Industries, Inc.) of 440 dtex in total fineness, 60 filaments in number of single yarns, and 33 t/m in number of twists and a polyester fiber (“TETORON” (registered trademark), polyethylene terephthalate fiber from Toray Industries, Inc.) of 44 dtex in total fineness and 18 filaments in number of single yarns were doubled and twisted for 210 t/m in number of twists to obtain a doubled

and twisted yarn, and a five-harness satin fabric was produced by a loom with the use of the doubled and twisted yarn as the warp yarn, and a polyester fiber of 26 s/2 (454 dtex) in total fineness “TETORON” (registered trademark), polyethylene terephthalate fiber from Toray Industries, Inc.) as the weft yarn. Thereafter, the fabric was refined in a refining tank at 80° C. and thermally set at 180° C.

Comparative Example 4

[0101] A PTFE fiber (“TOYOFLON” (registered trademark) from Toray Industries, Inc.) of 2660 dtex in total fineness, 360 filaments in number of single yarns, and 33 t/m in number of twists and a carbon fiber of 1980 dtex in total fineness, 3000 filaments in number of single yarns, and 33 t/m in number of twists (“TORAYCA” (registered trademark) from Toray Industries, Inc.) were doubled and twisted for 167 t/m in number of twists to obtain a doubled and twisted yarn, and a 2/2 twill fabric was produced by a loom with the use of the doubled and twisted yarn as the warp yarn and the weft yarn. Thereafter, the fabric was refined in a refining tank at 80° C. and thermally set at 180° C.

[0102] For the fabrics described in Examples and Comparative Examples, Tables 1 and 2 summarize the results of evaluating the configuration of the composite yarn, the fabric configuration, the kinetic friction coefficient, and the sliding durability distance.

TABLE 1

			Example 1	Example 2	Comparative Example 1	Example 3	Example 4	Example 5	
Configuration of composite yarn	Combined method	—	Doubling and twisting	Doubling and twisting	Doubling and twisting	Doubling and twisting	Doubling and twisting	Doubling and twisting	
	Mass ratio $\alpha$ of fluororesin fibers A in composite yarn	%	51%	51%	51%	51%	51%	51%	
	Fluororesin Fineness fiber A	dtex	880	880	880	880	440 × 2	880	
	Fiber B	Fiber type	Liquid crystal polyester fiber	Liquid crystal polyester fiber	Liquid crystal polyester fiber	Liquid crystal polyester fiber	Liquid crystal polyester fiber	Liquid crystal polyester fiber	
		Fineness	dtex	850	850	850	(425T × 2) 850	850	850
		Tensile strength	cN/dtex	19	19	19	19	19	19
		Tensile modulus of elasticity	cN/dtex	690	690	690	690	690	690
		Elongation	%	5.0	5.0	5.0	5.0	5.0	5.0
		Number of twists	t/m	33	33	33	0	33	0
		Twist coefficient	t/m · dtex <sup>0.5</sup>	962	962	962	0	962	0
Fabric configuration	Weave structure	—	3/1 twill	3/1 twill	3/1 twill	3/1 twill	3/1 twill	3/1 twill	
	Yarn used	Warp yarn	Composite yarn	Composite yarn	Composite yarn	Composite yarn	Composite yarn	Composite yarn	
		Weft yarn	Liquid crystal polyester fiber 1700T-288F	Composite yarn	PTFE fiber 1760T-240	Liquid crystal polyester fiber 1700T-288F	Liquid crystal polyester fiber 1700T-288F	Liquid crystal polyester fiber 1700T-288F	
	Weave density	Warp yarn	Number of yarns/2.54 cm	54	54	54	54	54	54
		Weft yarn	Number of yarns/2.54 cm	33	33	33	33	33	33
		Area ratio X of fluororesin fibers A in fabric surface	%	45	51	63	32	52	38

TABLE 1-continued

			Comparative					
			Example 1	Example 2	Example 1	Example 3	Example 4	Example 5
Properties	Mass ratio Y of fluoro-resin fibers A in fabric	%	32	51	70	32	32	32
	X/Y	—	1.41	1.00	0.90	1.00	1.63	1.19
	Kinetic friction coefficient		A	A	A	B	A	A
	Sliding durability distance	—	A	B	0	B	B	B

TABLE 2-1

			Comparative						
			Example 6	Example 7	Example 2	Example 8	Example 9	Example 10	
Configuration of composite yarn	Combined method	—	Doubling and twisting	Doubling and twisting	Doubling and twisting	Doubling and twisting	Doubling and twisting	Doubling and twisting	
	Mass ratio $\alpha$ of fluoro-resin fibers A in composite yarn	%	26%	26%	26%	51%	51%	51%	
	Fluoro-resin fiber A	Fineness	dtex	440	440	440	880	880	880
	Fiber B	Fiber type	—	Liquid crystal polyester fiber	Liquid crystal polyester fiber	Liquid crystal polyester fiber	Liquid crystal polyester fiber	Liquid crystal polyester fiber	Liquid crystal polyester fiber
		Fineness	dtex	1275	1275	1275	850	850	850
		Tensile strength	cN/dtex	19	19	19	16	8	4
		Tensile modulus of elasticity	cN/dtex	690	690	690	490	115	40
		Elongation	%	5.0	5.0	5.0	5.5	13.0	15.0
		Number of twists	t/m	33	33	33	0	33	0
		Twist coefficient	t/m · dtex <sup>0.5</sup>	1178	1178	1178	962	962	979
Fabric configuration	Weave structure	—	3/1 twill	3/1 twill	3/1 twill	3/1 twill	3/1 twill	3/1 twill	
	Yarn used	Warp yarn	—	Composite yarn	Composite yarn	Liquid crystal polyester fiber 1700T-288F	Composite yarn	Composite yarn	Composite yarn
		Weft yarn	—	Liquid crystal polyester fiber 1700T-288F	Composite yarn	Composite yarn	Poly-p-phenylene terephthalamide fiber 850T-144F	Polyester fiber 1670T-200F	Polyphenylene sulfide fiber 1760T-400F
	Weave density	Warp yarn	Number of yarns/2.54 cm	54	54	54	54	54	54
	Weft yarn	Number of yarns/2.54 cm	33	33	33	33	33	33	
Properties	Area ratio X of fluoro-resin fibers A in fabric surface	%	17	34	5	45	45	45	
	Mass ratio Y of fluoro-resin fibers A in fabric	%	15	26	10	32	32	32	
	X/Y	—	1.13	1.31	0.50	1.41	1.41	1.41	
	Kinetic friction coefficient		C	A	D	A	A	A	
	Sliding durability distance	—	C	B	E	A	B	C	

TABLE 2-2

			Comparative Example 3	Comparative Example 4	
Configuration of composite yarn	Combined method	—	Doubling and twisting	Doubling and twisting	
	Mass ratio $\alpha$ of fluoro resin fibers A in composite yarn	%	91%	57%	
	Fluoro resin fiber A	Fineness dtex	440	2660	
	Fiber B	Fiber type	—	Polyester fiber	
			44T-18F	Carbon fiber	
		Fineness dtex	44	1980	
		Tensile strength cN/dtex	4	18	
		Tensile modulus of elasticity cN/dtex	90	1300	
		Elongation %	40.0	1.0	
		Number of twists t/m	0	33	
	Twist coefficient t/m-dtex <sup>0.5</sup>	0	1468		
Fabric configuration	Weave structure	—	five-layered satin	2/2 twill	
	Yarn used	Warp yarn	—	Composite yarn	Composite yarn
		Weft yarn	—	Polyester fiber	Composite yarn
	Weave density	Warp yarn	Number of yarns/2.54 cm	50	8
		Weft yarn	Number of yarns/2.54 cm	68	8
	Area ratio X of fluoro resin fibers A in fabric surface	%	69	51	
	Mass ratio Y of fluoro resin fibers A in fabric	%	40	57	
X/Y	—	1.72	0.90		
Properties	Kinetic friction coefficient	—	A	A	
	Sliding durability distance	—	E	D	

1. A fabric wherein a composite yarn of fluoro resin fibers A and fibers B other than fluoro resin fibers is used for at least one of a warp yarn and a weft yarn, a mass ratio  $\alpha$  of the fluoro resin fibers A in the composite yarn is 5 to 70%, and a ratio X/Y of an area ratio X of the fluoro resin fibers A in a fabric surface to a mass ratio Y of the fluoro resin fibers A in the fabric is 1 or more and 5 or less.

2. The fabric according to claim 1, wherein the composite yarn is used for either the warp yarn or the weft yarn, and the fibers B are used as either the weft yarn or the warp yarn orthogonal to the composite yarn.

3. The fabric according to claim 1, wherein the area ratio X is 10% or more and 60% or less.

4. The fabric according to claim 1, wherein the composite yarn is a doubled and twisted yarn obtained by doubling and twisting the fluoro resin fibers A and the fibers B other than fluoro resin fiber.

5. The fabric according to claim 4, wherein the fibers B constituting the doubled and twisted yarn is a twisted yarn.

6. The fabric according to claim 1, wherein the fluoro resin fibers A are made from a polytetrafluoroethylene resin.

7. The fabric according to claim 1, wherein the fibers B are fibers that are 7 cN/dtex or more in tensile strength.

8. The fabric according to claim 7, wherein the fibers B are fibers that are 15 to 50 cN/dtex in tensile strength.

9. The fabric according to claim 1, wherein the fibers B are fibers that have a heat resistance temperature of 280° C. or higher.

10. The fabric according to claim 1, wherein the fibers B are fibers that are 450 to 800 cN/dtex in tensile modulus of elasticity.

11. The fabric according to claim 1, wherein the fibers B are organic fibers.

12. The fabric according to claim 1, wherein the fibers B are fibers selected from liquid crystal polyester fibers, para-aramid fibers, and polyparaphenylene benzobisoxazole fibers.

13. A robot arm cable cover comprising, in at least a part thereof, the fabric according to claim 1.

\* \* \* \* \*