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Sheathed Synthetic Fiber Rope

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Description

- 5 The invention relates to a sheathed synthetic fiber rope, preferably of aromatic polyamide, according to the preamble to Claim 1, and a process for manufacturing it according to the preamble to Claim 8.
- 10 In materials handling technology, especially on elevators, in crane construction, and in open-pit mining, moving ropes are an important element of machinery and subject to heavy use. An especially complex aspect is the loading of driven ropes, for example as they are used in elevator construction
- 15 and for suspended cable cars. In these instances the lengths of rope needed are large, and considerations of energy lead to the demand for smallest possible masses. High-tensile synthetic fiber ropes, for example of aromatic polyamides or aramides with highly oriented molecule chains, fulfil these
- 20 requirements better than steel ropes.

Such a sheathed synthetic fiber rope has become known from the applicant's EP 0 672 781 A1. There, the synthetic sheath is applied by extrusion in such a manner that a large

25 surface of adhesion to the strands is formed. However, when the rope bends on the rope sheave or pulley the strands perform compensatory movements which, under certain circumstances, can cause relative movement of the strands of different layers of strands. These movements are greatest in

30 the outermost layer of strands and particularly when the drive torque is transferred by friction to the section of rope lying in the angle of wrap of the rope sheave, can cause the sheath to lift off and form pile-ups. Such a change in the structure of the rope is undesirable because



it can cause the rope to have a short service life. The same applies to ropes wound on drums as they are used in mining.

5 The problem underlying the invention is that of proposing a sheathed synthetic fiber rope with a long service life, as well as a method for producing such a rope.

10 According to the invention this objective is fulfilled by means of a synthetic fiber rope with the characteristics stated in Claim 1. A solution for manufacturing a synthetic fiber rope is given by the characteristics of Claim 8.

15 The advantages resulting from the invention consist of a lasting bonding of the sheath in the outermost layer of strands. In addition to the former adhesive bonding to as large a contact surface as possible of the outermost layer of strands, according to the invention the sheath is fastened with anchoring means which are structurally anchored in the outermost layer of strands. Especially when
20 the join is in one piece, the bonding forces between the sheath and the anchoring means correspond to the strength of the material of the anchoring means, and are thereby many times greater than conventional adhesive forces. If the anchoring means are connected to the outermost layer of
25 strands by positive fit, separation of the sheath is then only possible with accompanying damage to the aramide fiber strands.

30 As a further advantage of integrating the anchoring means into the rope structure of the outer layer of strands in combination with the single piece bonding to the sheath, for example bonding with adhesive, as the rope passes over the traction sheave the anchoring means follow the movement and/or deformation of the outermost layer of strands. By
35 appropriate selection of a material with suitable elastic

deformability, the forces acting in the layer of aramide fibers and, as a result of the bending load, in the sheath can be mutually balanced out, thereby preventing relative movement between the sheath and the layer of strands.

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In a further development of the invention, the anchoring means and the sheath are made of weldable or vulcanizable materials. This choice of materials makes it possible to join the anchoring means and the sheath with no additional bonding agent. At the same time, the joint is permanent, displays material behavior identical to that of the joined parts themselves, and is therefore equivalent to a single-piece construction of the anchoring means and the sheath. The joint is particularly homogeneous if the anchoring means and the sheath are made of identical material. The uniform material parameters then occurring make it simpler to join the parts to be joined with uniform molecular bonding.

In addition to the functional advantages achieved by the invention, manufacturing sheathed synthetic fiber ropes according to the invention can be done simply, and with minimal modification to conventional rope laying machines. Over a rope core manufactured in known manner, load-bearing fiber strands with anchoring means are laid in the outermost layer of strands. The fiber strands are then thermally or chemically pre-treated before the sheath of synthetic material is applied, and the fiber strands then form a molecular bond with the means of anchoring. With conventional rope laying machines it is adequate to retrofit a pre-treatment station, apart from which there is only adjustment work to be done.

If the anchoring means and the sheath are welded to each other, essentially a heating device must be provided to heat the anchoring means so that when the sheath is extruded,

permanent fusion of the sheath and the anchoring means takes place.

In a further preferred alternative process the sheath is vulcanized onto the outermost layer of strands. In this
5 embodiment a substrate is applied to the anchoring means by use of a suitable pre-treatment station which slightly corrodes them, and in this way prepares them for molecular interlinking with the extruded sheath.

- 10 In a preferred embodiment of the invention the anchoring means take the form of one or more anchoring strands which together with load-bearing aramide fiber strands are laid into the outermost layer of strands. The twisted rope structure resulting from the helical twisting of the strands
15 around each other already provides in a simple manner a positive fit of the anchoring strands on the outermost layer of strands. The anchoring of the sheath can be adjusted via the number of anchoring strands laid in the outer layer. A particularly good positive fit is achieved with this
20 embodiment if the anchoring strands have a smaller diameter than the load-bearing aramide fiber strands. The circumference of each anchoring strand is squeezed between two aramide fiber strands of larger diameter, and thereby anchored in the layer of strands. Pre-manufactured anchoring
25 strands can be processed together with the aramide fiber strands by the same rope-laying machine.

- Furthermore, the anchoring means can take the form of anchoring fibers which are twisted together with aramide
30 fibers and fixed to them to form load-bearing strands for the outermost layer of strands. The anchoring fibers are arranged in the outermost layer of fibers of the strands, and are also bonded as a single piece to the sheath, which is subsequently extruded on to them. Having a large number
35 of such anchoring strands creates a large total bonding area

between the sheath and its anchoring which strengthens the bond and also lengthens the service life of the rope.

Futhermore, the thin anchoring strands can be heated to melting temperature in a short space of time and with
5 relatively low expenditure of energy, as a result of which this embodiment is advantageous for continuous extrusion of the sheath onto the rope.

The synthetic fiber rope according to the invention affords
10 advantages in elevator installations, for example, where it connects the car frame of a car guided in an elevator hoistway to a counterweight. For the purpose of raising and lowering the car and counterweight, the rope passes over a traction sheave which is driven by a drive motor. As the
15 synthetic fiber rope according to the invention passes over the traction sheave, no relative movement occurs between the rope sheath and the synthetic fiber rope.

Further details of the invention are described below by
20 reference to the three exemplary embodiments of the invention illustrated in the drawing. The drawings show:

Figure 1 A perspective view of a first
 exemplary embodiment of the drive
25 rope with anchoring strands according to the invention;

Figure 2 A cross-sectional view of a second
 exemplary embodiment of the drive rope
30 with enveloping of the strands according to the invention;

Figure 3 A cross-sectional view of a third
 exemplary embodiment of the invention
35 with anchoring fibers.

Figure 1 shows a first exemplary embodiment of a sheathed rope 1 according to the invention. The rope 1 is constructed of a core strand 2, about which in a first direction of lay 3 five identical strands 4 of a first layer of strands 5 are laid helically, and with which ten strands 4, 6 of a second layer of strands 7 are laid in parallel lay in a balanced ratio between the direction of twist and the direction of lay of the fibers and strands. A different number of laid strands 4 can be selected to correspond to the specific requirements and is not determined by the number in this exemplary embodiment. Load-bearing strands 2, 4, 6, 9 which are used for the rope 1 are twisted or laid from individual aramide fibers and treated with an impregnating substance, for example polyurethane solution, which protects the aramide fibers.

The rope core 8 is surrounded by an intersheath 12 of polyurethane or polyester, onto which a covering layer of strands 11 is laid. The intersheath 12 is extruded onto the rope core 8 immediately before the covering layer of strands 11 is laid. It prevents contact between the covering layer of strands 11 and the second layer of strands 7, and thereby wear of the strands 4, 6 and 9 being caused by their rubbing against each other when the rope 1 runs over the traction sheave and relative movement then occurs between the strands 4, 6, 9. The intersheath 12 also serves to transfer internal moments between the rope core 8 and the covering layer of strands 11.

The covering layer of strands 11 is laid in a second direction of lay 10 which is opposite to the first direction of lay 3. When the rope 1 is loaded longitudinally, the covering layer of strands 11 gives rise to a torque opposite in direction to that of the parallel laid rope core 8.

A rope sheath 14 of polyurethane surrounds the covering layer of strands 11 and ensures the desired coefficient of friction on the traction sheave. Furthermore, the

5 polyurethane is so resistant to abrasion that no damage occurs as the rope 1 passes over the traction sheave. By means of, for example, welding, vulcanization, or use of adhesive, the rope sheath 14 is bonded in one piece to anchoring strands 13 of polyurethane. Here, by way of

10 example, nine of these polyurethane strands 13 alternating with nine aramide fiber strands 9, and each lying between two adjacent aramide fiber strands 9, are laid together to form the covering layer of strands 11.

15 In Figure 1 the aramide fiber strands 9 and the polyurethane strands 13 are shown equally thick, but the positive fit of the polyurethane strands 13 to the covering layer of strands 11 can be improved further if the polyurethane strands 13 are thinner than the aramide fiber strands 9. The

20 circumferences of the thinner polyurethane strands 13 are squeezed between the adjacent aramide fiber strands 9 of larger diameter and thereby pressed in a radial direction onto the intersheath 12.

25 The rope sheath 14 is extruded onto the covering layer of strands 11 in a pass-through process. During the extrusion process the flowable synthetic material is pressed into all the interstices in the surface of the covering layer of strands, so that a large surface of adhesion is formed.

30 Before extruding the rope sheath 14, the polyurethane strands 13 are heated to melting temperature so that during extrusion the rope sheath 14 and the polyurethane strands 13 are welded together. The permanent single-piece bonding thereby created provides the rope sheath 14 with a permanent

35 connection to the high-tensile rope 1 via the improved

positive fit of the polyurethane strands to the covering layer 11.

The rope sheath can also be extruded in two layers. The foregoing description then applies identically to the first layer of sheath applied. Figure 2 shows a cross-sectional view of a second exemplary embodiment of a sheathed rope 20 according to the invention. With regard to function and construction, the rope core 21 and the intersheath 22 which is firmly bonded to it correspond to relative parts of the first exemplary embodiment described above. A covering layer 23 of seventeen aramide fiber strands 24 is laid onto the intersheath 22. Each individual aramide fiber strand 24 is given a separate, seamless jacket 25 of polyurethane. The aramide fiber rope 20 described so far is surrounded by a rope sheath 26. The rope sheath 26, as also the jacket 25 surrounding the aramide strands 24, consists of thermoplastically formable polyurethane and this material is welded in one piece to the covering layer of strands 23 along the corresponding external surface of the jacket 25. Via these permanent molecular bonds the rope sheath 26 is bonded with positive fit to the aramide fiber rope 20. In this exemplary embodiment too, anchoring means in the form of the jacket 25 are first anchored in the rope structure with positive fit, and immediately prior to extrusion of the rope sheath 26 are permanently bonded to the rope sheath 26 by heating, bonding with adhesive, lightly corroding or vulcanizing.

In Figure 3 an aramide fiber rope 30 is shown as a third exemplary embodiment of the invention. The rope core structure 31, the intersheath 32 surrounding it, and the number of strands 33 of the covering layer of strands 34 are again identical to those in the two exemplary embodiments described above. A rope sheath 37 surrounds the covering

layer of strands 34 to which it is joined with positive fit. The polyurethane fibers 35 are arranged in the outermost layer of fibers, that is to say, on the external sheath surface of the strands 33. The fact that the strands 33 are wound helically around the intersheath 32 ensures that the polyurethane fibers 35 at least in part lie against the surface adjacent to the rope sheath 37. Shortly before extruding the rope sheath 37, the polyurethane fibers 35 are heated and fuse with the rope sheath 37 which is pressed on tightly. As a component of the strands 33 the polyurethane fibers 35 are bonded with positive fit to the strand structure and the covering layer of strands 34. Consequently, the rope sheath 37 which is bonded in one piece to the polyurethane fibers 35 is also permanently anchored with positive fit to the aramide fiber rope 30 via a large number of such polyurethane fibers 35. Moreover, the described exemplary embodiments of the invention can be systematically combined with each other to create a specific desired fastening of the sheath.

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As well as being used as a means of suspension in elevator installations, the rope can be used in a wide range of equipment for handling materials, examples being hoisting gear in mines, building cranes, indoor cranes, ship's cranes, aerial cableways, and ski lifts, as well as a means of traction on escalators. The drive can be applied by friction on traction sheaves or Koepe sheaves, or by the rope being wound on rotating rope drums. A hauling rope is to be understood as a moving, driven rope, which is sometimes also referred to as a traction or suspension rope.

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List of Reference Numbers

	1	Rope
	2	Core strand
5	3	First direction of lay
	4	Thin strand
	5	First layer of strands
	6	Thick strand
	7	Second layer of strands
10	8	Rope core
	9	Aramide fiber strands
	10	Second direction of lay
	11	Covering layer of strands
	12	Intersheath
15	13	Polyurethane strand
	14	Rope sheath
	20	Rope
	21	Rope core
	22	Intersheath
20	23	Covering layer of strands
	24	Aramide fiber strand
	25	Jacket
	26	Rope sheath
	30	Rope
25	31	Rope core
	32	Intersheath
	33	Strand
	34	Covering layer of strands
	35	Polyurethane fiber
30	36	Aramide fiber
	37	Rope sheath

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Sheathed Synthetic Fiber Rope

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**Claims**

- 5 1. Synthetic fiber rope comprising an outermost layer (11)
of load-bearing synthetic fiber strands (9) which are
laid together with a rope core (8) formed of load-
bearing synthetic fiber strands (2, 4, 9) laid together
10 in layers, and a sheath (14) joined to the outermost
layer of strands (11)
characterized in that
in the outermost layer of strands (11, 23, 34) anchoring
means (13, 25, 35) are laid which can be permanently
fastened to the sheath (14, 26, 37).
- 15 2. Synthetic fiber rope according to Claim 1,
characterized in that
the anchoring means (13, 25, 35) and the sheath (14, 26,
37) are made of materials which can be welded or
20 vulcanized.
3. Synthetic fiber rope according to Claim 1 or 2
characterized in that
the anchoring means take the form of at least one
25 anchoring strand (13) laid in the outermost layer of
strands (11) with load-bearing aramide fiber strands
(9).
- 30 4. Synthetic fiber rope according to Claim 1 or 2
characterized in that
the anchoring means take the form of at least one
anchoring fiber (35) which in the outermost layer of
strands (34) is laid together with aramide fibers (36)
to form load-bearing strands (33), the anchoring fiber
35 (35) being positioned in the outermost layer of fibers





of the load-bearing strands (33).

5. Process for manufacturing a sheathed rope in which load-bearing synthetic fiber strands (9, 24, 33) having
5 anchoring means (13, 25, 35) in an outermost layer of strands (11, 23, 34) are laid together with the rope layer adjacent to them of a rope core (8, 21, 31) which carries them, subsequent to which a sheath (14, 26, 37) is applied to them with permanent adhesion by means of
10 the extrusion process characterized in that the anchoring means (13, 25, 35) are pre-treated and when the sheath (14, 26, 37) is applied enter into a molecular bond and become permanently bonded with the
15 sheath (14, 26, 37).
6. Process according to Claim 5, characterized in that the anchoring means (13, 25, 35) are heated to melting
20 temperature before the sheath (14, 26, 37) is extruded onto, and welded to, the anchoring means (13, 23, 34).
7. Process according to Claim 6, characterized in that
25 the anchoring means (13, 25, 35) are chemically pre-treated before the sheath (14, 26, 37) is vulcanized onto the outermost layer of strands (11, 23, 34).

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