Reinforced synthetic cable for lifts

The invention relates to a cable or belt as support means for lifts, according to the definition of the patent claims.

A drive pulley is often used in a lift in order to move a cage. In the case of such a drive pulley lift, drive pulley and cage are connected together by way of, for example, a cable. A drive sets the drive pulley into rotational movement. The rotational movement of the drive pulley is converted into movement of the cage by friction couple between drive pulley and cable. The cable then serves as combined support and drive means, whilst the drive pulley serves as force transmission means:

- in its function as support means the cable supports an operating weight of the lift, consisting of the empty weight of the cage, the useful load of the lift, an optional counterweight and the own weight of the cable. The cable is in that case principally loaded by tension forces. For example, cage and counterweight depend along gravitational force at the support means.

- in its function as drive means for movement of the cage the cable is pressed against a drive surface of the drive pulley. The cable is in that case subjected to compression and bending loads. For example, the cable is pressed by the operating weight of the lift against a circumference of the drive pulley so that cable and drive pulley are disposed in friction couple.

- in its function as force transmission means the drive pulley transmits the force of the drive to the cable. Important parameters in that case are a material-specific coefficient of friction between drive pulley and cable and a construction-specific angle of looping of the drive pulley by the cable.

Up to now steel cables are used in lift construction, which cables are connected with drive pulley, cage and counterweight. However, the use of steel cables is accompanied by certain disadvantages. Due to the high intrinsic weight of the steel cable, limits are placed on the lifting height of a lift installation. Moreover, the coefficient of friction between the metal drive pulley and the steel cable is so small that the coefficient of friction has to be increased by various measures such as special groove shapes or special groove linings in the drive pulley or by enlargement of the angle of looping. In addition, the steel cable acts

as a sound bridge between the drive and the cage which means a reduction in travel comfort. Expensive constructional measures are necessary in order to reduce these undesired effects. Moreover, steel cables tolerate, by comparison with synthetic material cables, a lesser bending cycle rate, are subject to corrosion and have to be regularly serviced.

Synthetic material cables normally consist of several load-bearing strands which are wound together and/or packed together, as can be inferred from the Patents US 4 877 422, US 4 640 179, US 4 624 097, US 4 202 164, US 4 022 010 and EP 0 252 830.

Patents US 5 566 786 and US 2002/0000347 disclose the use of a synthetic material cable as support or drive means for lifts, which is connected with the drive pulley, cage and counterweight, wherein the cable consists of load-bearing synthetic material strands. The strand layer is covered, in US 5 566 786, by a sheath, the task of which consists of ensuring the desired coefficient of friction relative to the drive pulley and of protecting the strands against mechanical and chemical damage and ultraviolet radiation. The load is borne exclusively by the strands.

Notwithstanding the substantial advantages relative to steel cables, the synthetic material cables described in Patent US 5 566 786 also demonstrate significant limitations, as also stated in US 2002/0000347.

Synthetic material cables demonstrate a very good longitudinal strength, which is, however, opposed by poor radial strength. The synthetic material cables tolerate, with difficulty, the load which is exerted on the outer surface thereof and which can lead to an undesired shortened service life of the cable. Finally, the modulus elasticity of the material cables currently in use is too small for lifts with greater lifting heights: undesired elongations of the cable occur and troublesome oscillations of the lift which is set in motion are noticed by the user, particularly when the length of the cable has exceeded a specific limit.

Belts as support or drive means are known from US 2002/0000347.

The object of the present invention is to propose a cable or belt as support means or drive means for lifts of the kind stated in the introduction, which does not have the aforesaid disadvantages and by means of which travel comfort and safety are increased. In

particular, the following disadvantages shall be eliminated: the undesired shortened service life of the cable, the too-small modulus of elasticity of the cable, the undesired elongations of the cable and the troublesome oscillations of the lift set in motion.

This object is fulfilled by the invention in accordance with the definition of the patent claims.

The advantages achieved by the invention are essentially to be seen in that the strands of a sheathed cable or belt, which consists of several layers, of synthetic material are reinforced by the introduction of a second phase into the aramide forming the fibres and thus have a higher modulus of elasticity than that of the unreinforced strands.

According to the classic definition of physical chemistry, by 'phase' there is here meant a solid, fluid or gaseous body having physical and chemical properties, such as, for example, composition, modulus of elasticity, density, etc., which are homogeneous or at least vary without discontinuity (see P. Atkins, 'Physikalische Chemie', VCH, Weinheim, 1987, page 201).

A phase is formally defined according to Gibbs as follows: a phase is a state of material in which with respect to its chemical composition and with respect to its physical state it is completely uniform.

This definition corresponds with the usual use of the word 'phase'. According to that, a gas or a gas mixture is a single phase; a crystal is a single phase; and two liquids fully miscible with one another similarly form a single phase. In addition, ice is a single phase, even if it is broken into small fractions. A mush of ice and water, thereagainst, is a system with two phases, even if it is difficult to localise the phase boundaries in this system.

An alloy of two metals is a two-phase system when the two metals are not miscible, but a single-phase system when they are miscible with one another.

The reinforced cable obtained demonstrates a higher modulus of elasticity in longitudinal direction than that of the unreinforced cable. Moreover, the reinforced cable obtained also demonstrates a higher modulus of elasticity, a higher strength and higher breakage strain in radial direction and a longer service life than those of the cable without reinforcement.

The invention is explained in more detail in the following by reference to forms of embodiment by way of example according to Figures 1 to 9, in which:

Fig. 1 shows a section through a conventional synthetic material cable according to the previous state of the art,

Fig. 2 shows a cogged belt,

Fig. 3 shows a poly-V-belt,

Fig. 4 shows a twin cable (twin rope),

Fig. 5 shows a perspective illustration of the conventional synthetic material cable according to the previous state of the art,

Fig. 6 shows a section through a reinforced fibre according to the invention,

Fig. 7 shows a perspective illustration of the reinforced fibre according to the invention,

Fig. 8 shows different geometric forms of embodiment of the second phase reinforcing the fibre and

Fig. 9 shows a perspective illustration of the reinforced fibre according to the invention, if the reinforcing second phase consists of fibres which are oriented in length and which are incorporated in the matrix of aramide and extend parallel to the fibres of aramide.

Fig. 1 shows a section through a conventional synthetic material cable 1. A sheath 2 surrounds an outermost strand layer 3. The sheath 2 of synthetic material, for example polyurethane, increases the coefficient of friction of the cable 1 on a drive pulley. The outermost strand layer 3 must have such high adhesion forces relative to the sheath 2 that this does not displace due to the thrust forces arising when the cable 1 is loaded or do not form wrinkles. These adhesion forces are achieved in that the synthetic material sheath 2 is injection-moulded (extruded) in place so that all interstices in the outer strand carrier are filled and a large retention area is formed (see EP 0 672 781). The strands 4 are twisted

or laid from individual fibres 5 of aramide. Each individual strand 4 is treated with an impregnant, for example polyurethane solution, for protection of the fibres 5. The reverse bending strength of the cable 1 is dependent on the proportion of polyurethane of each strand 4. The higher the proportion of polyurethane, the higher the reverse bending strength. However, with an increasing polyurethane proportion the load-bearing capability diminishes and the modulus of elasticity of the synthetic fibre cable 1 decreases for the same cable diameter. The polyurethane proportion for impregnation of the strands 4 can lie between, for example, ten and sixty percent depending on the respectively desired reverse bending strength and transverse pressure sensitivity. Advantageously, the individual strands 4 can also be protected by a braided envelope of polyester fibres.

In order to avoid wear of the strands by mutual friction on the drive pulley a friction-reducing intermediate casing 7 is accordingly formed between the outermost strand layer 3 and the inner strand layer 6. Thus, in the case of the outermost strand layer 3 and in the case of the inner strand layers 6, which execute the majority of relative movements during bending of the cable at the drive pulley, the wear is kept small. Another means for prevention of friction wear at the strands 4 can be a resilient filler which connects the strands 4 together without unduly reducing the flexibility of the cable 1.

A strand 4 is typically produced as follows: 1,000 fibres 5 of 12 microns diameter form one yarn. Eleven to twelve yarns are thereafter laid to form a strand 4.

Obviously, the expert with knowledge of the present invention can also use the load-bearing cable without employment of a drive pulley. In addition, the expert can use an embodiment as a double cable (twin rope) or as a belt as shown in Figs. 2 to 4. Fig. 2 shows a cogged belt, Fig. 3 shows a poly-V-belt and Fig. 4 shows a double cable.

As distinct from a pure retaining cable, driven lift cables must be very compact and firmly twisted or braided so that they do not deform on the drive pulley or begin to rotate as a consequence of the intrinsic twist or deflection. The gaps and cavities between the individual layers of the strands 4 can therefore be filled by means of filler strands 9 which can have a supporting effect relative to the other strands 4 in order to obtain an almost circular strand layer 6 and increase the degree of filling and in order to form the circumferential envelope of the cable to be more round. These filler strands 9 consist of synthetic material, for example of polyamide.

The fibres 5, which consist of intensely oriented molecular chains, of aramide have a high tensile strength. By contrast to steel, the fibre 5 of aramide has, however, a rather low transverse strength due to its atomic construction. For this reason, conventional steel cable locks cannot be used for cable end fastening of synthetic fibre cables 1, since the clamping forces acting in these components significantly reduce the breakage load of the cable 1. A suitable cable end connection for synthetic fibre cables 1 has already become known through PCT/CH94/00044.

Fig. 5 shows a perspective illustration of the construction of the synthetic fibre cable 1 according to the invention. The strands 4 twisted or laid from fibres 5 of aramide are laid, inclusive of the filler strands 9, around a core 10 as layers with lefthand twist or righthand twist. The friction-reducing intermediate casing 7 is disposed between an inner and the outermost strand layer 3. The outermost strand layer 3 is covered by the sheath 2. The surface 11 of the sheath 2 can be structured for determining a defined coefficient of friction. The task of the sheath 2 consists of ensuring the desired coefficient of friction relative to the drive pulley and of protecting the strands 4 against mechanical and chemical damage and ultraviolet radiation. The load is borne exclusively by the strands 4. The cable 1 constructed from fibres 5 of aramide has a substantially higher load-bearing capability by comparison to a steel cable for the same cross-section and has only a fifth to a sixth of the specific weight. Accordingly, for the same load-bearing capability the diameter of a synthetic fibre cable 1 can be reduced relative to a conventional steel cable. Through use of the above-mentioned materials the cable 1 is entirely protected against corrosion. Servicing as in the case of steel cables, for example in order to grease the cables, is no longer necessary.

Fig. 6 shows a schematic illustration of a section through a reinforced cable 5 of aramide in accordance with the invention, whilst Fig. 7 reproduces a perspective illustration of the fibre reinforced in accordance with the invention. The phase distribution is carried out in such a manner that aramide forms the first phase or base material and the reinforcing particles form the second phase. Particles 12, also termed second phase, are introduced and distributed in the base material 13. The second phase demonstrates a higher modulus of elasticity than that of the first phase 13 or demonstrates at least mechanical and chemical properties of such a kind that the modulus of elasticity of the reinforced fibre of aramide is higher than that of the unreinforced fibre of aramide.

The second phase 12 can consist of, for example, a very hard synthetic material, a stiffer polymer than aramide, ceramic, carbon, glass, steel, titanium, particularly metal alloys and/or intermetallic phases. There is to be understood by 'stiff' a higher modulus of elasticity than that of aramide.

The geometric form of the particles 12 can lead to a distribution of spheres, capsules, globules, short and/or long fibres. Fig. 8 shows, for example, different geometric forms of embodiment of the particles, which reinforce the fibre, of the second phase, which can adopt the form of spheres a, approximately spherical grains b, discs or small plates c, short fibres d or long fibres e, which are distributed in the matrix of aramide.

In the extreme case the fibres of the second phase 12 can be as long as the fibres 5 of aramide and extend, and be incorporated, parallelly thereto as is illustrated in Fig. 9.

The distribution and density of the particles 12 is preferably homogeneous in aramide 13. In the case of short and/or long fibres the orientation of the fibres can be random, as illustrated in Fig. 7, or have a preferential direction relative to the longitudinal direction of the fibres 5, as, for example, in Fig. 9.

Thanks to the effect of the reinforcing particles 12 in the first phase 13 the modulus of elasticity of the entire fibre in the longitudinal direction and/or in the transverse direction of the fibre 5 is increased. In addition, the breakage strain of the cable is increased and the service life of the cable extended by comparison with the case of the unreinforced cable.

The introduction of the second phase in order to optimise the mechanical properties of an aramide cable enables the known disadvantages of use of such a cable as support means for lifts to be avoided. The modulus of elasticity of the entire cable is so increased in longitudinal direction as well as in transverse direction that the requirements of the cable as support means for a lift installation with high lifting height can be achieved.

The service life as well as the breakage strength and elongation strength of the aramide cable reinforced in accordance with the invention are substantially increased and thus satisfy by far the demands, which are imposed in the field of lifts, with respect to safety. At the same time, the weight of the reinforced aramide cable remains substantially smaller than that of a corresponding steel cable with comparable strength.

Methods for the production of a fibre, which is reinforced by microfibres, of aramide in such a manner as that of the present invention are disclosed in, for example, US 2001/0031594.

The base material 13 of the fibres 5 can also be replaced by other synthetic compositions which have a sufficient strength. The reinforcing particles 12 beyond this enable the use of materials as base material 13 which would not otherwise come into question without the positive effect of the reinforcement.

The introduction of reinforcing particles 12 into the first phase 13 is also conceivable in lift cables which have a structure and arrangement of the strands different from that of the cable illustrated in Fig. 5.

Apart from lift cables, lift belts can also be reinforced by particles 12 and thus have more suitable mechanical properties in order to be used as support means or drive means for lifts.

Patent Claims

1. Cable or belt for lifts (1), with load-bearing strands (4), which strands consist of several fibres (5) and are surrounded by a sheath (2), characterised in that the material of the fibres (5) consists of at least two phases (12, 13).

2. Cable or belt according to claim 1, characterised in that a first phase (13) of the material of the fibres (5) consists of a base material such as steel, plastic, synthetic compositions, aramide, Zylon, and the second phase (12) of the material of the fibres (5) consists of a reinforcing material which increases the modulus of elasticity of the fibres in the longitudinal and/or radial direction of the fibres.

3. Cable or belt according to claim 2, wherein the reinforcing material of the fibres has a higher modulus of elasticity than that of the base material.

4. Cable or belt according to any one of claims 1 to 3, wherein the reinforcing material is arranged and distributed in the form of long and/or short fibres, capsules, spheres, in the base material, which forms a matrix.

5. Lift with a cable or belt with load-bearing strands, which strands consist of several fibres and are surrounded by a sheath, characterised in that the material of the fibres consists of at least two phases.

6. Lift with a cable or belt according to claim 5, characterised in that a first phase of the material of the fibres consists of a base material such as steel, plastic, synthetic compositions, aramide, Zylon, and the second phase of the material of the fibres consists of a reinforcing material which increases the modulus of elasticity of the fibres in the longitudinal and/or radial direction of the fibres.

7. Lift with a cable or belt according to claim 6, wherein the reinforcing material of the fibres has a higher modulus of elasticity than that of the base material.

8. Lift with a cable or belt according to any one of claims 5 to 7, wherein the reinforcing material is arranged and distributed in the form of long and/or short fibres, capsules, spheres, in the base material which, forms a matrix.

9. Method of producing a lift cable or lift belt with load-bearing strands, which strands consist of several fibres and are surrounded by a sheath, characterised in that at least two phases are combined and/or mixed in order to form the fibres.

10. Method of producing a lift cable or lift belt according to claim 9, characterised in that a first phase of the material of the fibres consists of a base material such as steel, plastic, synthetic compositions, aramide, Zylon, and the second phase of the material of the fibres consists of a reinforcing material which increases the modulus of elasticity of the fibres in the longitudinal and/or radial direction of the fibres.

11. Method of producing a lift cable or lift belt according to claim 10, wherein the reinforcing material of the fibres has a higher modulus of elasticity than that of the base material.

12. Method of producing a lift cable or lift belt according to one of claims 9 to 11, wherein the reinforcing material is arranged and distributed in the form of long and/or short fibres, capsules, spheres, in the base material, which forms a matrix.