Claims

1. A rope of a lifting device for a transport elevator,
- the rope extending in a longitudinal direction and the rope having a width and a thickness in a transverse direction that is perpendicular to the longitudinal direction, wherein the width is greater than the thickness,
- the rope comprising a load-bearing part extending in the longitudinal direction, which load-bearing part comprises a reinforced composite material having a number of reinforcing fibers enclosed in a polymer matrix, and
- the rope comprising one or more optical fibers
characterized in that
the one or more optical fibers are enclosed together with the load-bearing part by the polymer matrix,
wherein the reinforcing fibers are aligned in the longitudinal direction and are distributed homogeneously in the polymer matrix.

2. A rope according to the preceding claim, **characterized** in that the rope has a uniform structure along its whole length, and in that the load-bearing part comprises prepreg reinforcement layers laminated together, wherein the one or more optical fibers are laminated between and/or on a surface of the prepreg reinforcement layers.

3. A rope according to any one of the preceding claims, **characterized** in that the one or more optical fibers are distributed within the reinforcing fibers laminated into the polymer matrix.

4. A rope according to any one of the preceding claims, **characterized** in that the one or more optical fibers have a length being equal or greater than a length of the load-bearing part, and travel continuously in the longitudinal direction along the length of the load-bearing part.

5. A rope according to claim 4, characterized in that the one or more optical fibers travel along the length of the load-bearing part more than once.

6. A rope according to any one of the preceding claims, **characterized** in that a light pulse is input into and received from the one or more optical fibers at the same end of the rope or at opposite ends of the rope.

7. A rope according to the preceding claim 6, **characterized** in that the one or more optical fibers comprise single-mode or multimode fibers and the light pulse is generated with a laser transmitter or with a LED light source.

8. A rope according to any one of the preceding claims, **characterized** in that the one or more optical fibers comprise a Fabry-Pérot-type sensor fiber.

9. A rope according to any one of the preceding claims, **characterized** in that the one or more optical fibers comprises a Bragg grating structure.

10. A rope according to any one of the preceding claims, **characterized** in that the one or more optical fibers function as a Brilloun distributed fiber sensor.

11. A rope according to any one of the preceding claims, **characterized** in that the one or more optical fibers comprise a fiber, in which time-of-flight of a light pulse is measured.

12. A rope according to any one of the preceding claims, **characterized** in that the reinforcing fibers comprise one or more of a carbon-fiber, an aramid-fiber and a glass-fiber.

13. A rope according to any one of the preceding claims, **characterized** in that the one or more fibers comprise one or more fiber bundles.

14. A rope arrangement of a lifting device for a transport elevator, which rope arrangement comprises a plurality of ropes, at least one of which comprise a rope according to any one of the preceding claims 1-13.

15. An elevator having an elevator car, a traction sheave, and a power source for rotating the traction sheave, **characterized** in that the elevator car is arranged to be moved by a rope according to any one of claims 1-13 and/or rope arrangement according to claim 14.

16. An elevator according to claim 15, **characterized** in that the rope and/or the rope arrangement is arranged to move the elevator car and a counterweight.

17. An elevator according to any one of the preceding claims 15-16, **characterized** in that the rope is arranged to operate as an overspeed governor rope and/or a compensating rope.

18. An elevator according to any one of the preceding claims 15-17, **characterized** in that the elevator comprises means for monitoring a condition of the one or more optical fibers, which means monitor a change in the condition of each optical fiber.

19. An elevator according to claims 18, **characterized** in that the condition comprises a strain and/or a displacement of the or each optical fiber.

20. A condition monitoring method for a rope of a lifting device for a transport elevator, **characterized** in that in the condition of a rope according to any one of the preceding claims 1-13 and/or a rope arrangement according to claim 14 is monitored by monitoring a condition of the or each optical fiber and if it is detected that the condition of the optical fiber has changed over a certain pre-defined limit value, a need to replace or overhaul the rope or ropes is diagnosed and rope replacement work or rope maintenance work is started.

21. A method according to the preceding claim 20, **characterized** in that the condition comprises a strain and/or a displacement of the or each optical fiber.

22. A method according to any one of the preceding claims 20-21, **characterized** in that the or each optical fiber comprises a single-mode or multimode fiber and a light pulse is input into the optical fiber, wherein the light pulse is generated with a laser transmitteror with a LED light source.

23. A method according to any of the preceding claims 20-22, **characterized** in that the or each optical fiber comprises a sensor fiber and a reference fiber arragned to eliminate common mode errors.

24. A method according to any one of the preceding claims 20-23, **characterized** in that the or each optical fiber comprises a Fabry-Pérot-type sensor fiber, with which the condition is monitored.

25. A method according to any one of the preceding claims 20-23, **characterized** in that the or each optical fiber comprises a Bragg grating structure, with which the condition is monitored.

26. A method according to any one of the preceding claims 20-23, **characterized** in that the or each optical fiber functions as a Brilloun distributed fiber sensor, with which the condition is monitored.

27. A method according to any one of the preceding claims 20-23, **characterized** in that the or each optical fiber comprises a fiber, in which time-of-flight of a light pulse is measured, and with which the condition is monitored..

28. A method according to any one of the preceding claims 20-27, **characterized** in that in the condition is monitored in a number of ropes and when the condition in different ropes differ sufficiently from each other, a need to

replace or overhaul the rope or ropes is diagnosed and rope replacement work or rope maintenance work is started.

Claims

1. A rope (10, 20, 30, 40, 50, 60, 70, 80, 90, 100) of a lifting device, particularly of a passenger transport elevator and/or freight transport elevator,
- the width of which rope is greater than the thickness in the transverse direction of the rope,
- which rope comprises a load-bearing part (11, 21, 31, 41, 51, 61, 71, 81, 91) in the longitudinal direction of the rope, which load-bearing part comprises carbon-fiber reinforced, aramid-fiber reinforced and/or glass-fiber reinforced composite material in a polymer matrix, and
- which rope comprises one or more optical fibers and/or fiber bundles (2) in connection with the load-bearing part (11, 21, 31, 41, 51, 61, 71, 81, 91)
characterized in that
the aforementioned optical fiber and/or fiber bundle (2), which comprises a number of optical fibers, is laminated inside the load-bearing part (11, 21, 31, 41, 51, 61, 71, 81, 91) and/or the aforementioned optical fiber and/or fiber bundle (2) is glued onto the surface of the load-bearing part (11, 21, 31, 41, 51, 61, 71, 81, 91) and/or the aforementioned optical fiber and/or fiber bundle (2) is embedded or glued into the polymer envelope surrounding the load-bearing part (11, 21, 31, 41, 51, 61, 71, 81, 91).

2. A rope according to the preceding claim, **characterized** in that the structure of the aforementioned rope (10, 20, 30, 40, 50, 60, 70, 80, 90, 100) continues essentially the same for the whole length of the rope, and in that the aforementioned carbon-fiber reinforced, aramid-fiber reinforced and/or glass-fiber reinforced load-bearing part (11, 21, 31, 41, 51, 61, 71, 81, 91) comprises prepreg reinforcement layers laminated together and the aforementioned optical fiber and/or fiber bundle (2) is laminated between and/or on the surface of the reinforcement layers.

3. A rope according to any of the preceding claims, **characterized** in that the

aforementioned carbon-fiber reinforced, aramid-fiber reinforced and/or glass-fiber reinforced load-bearing part (11, 21, 31, 41, 51, 61, 71, 81, 91) comprises unidirectional reinforcing fibers laminated into the polymer matrix, and the aforementioned optical fiber and/or fiber bundle (2) is arranged to be mixed into the reinforcement.

4. A rope according to any of the preceding claims, **characterized** in that the aforementioned load-bearing part (11, 21, 31, 41, 51, 61, 71, 81, 91) comprises the aforementioned optical fiber and/or fiber bundle (2), which is essentially the length of the load-bearing part, preferably longer, and is arranged to travel continuously in the direction of the load-bearing part essentially from its first end to its second end at least once, more preferably more than once, most preferably more than twice.

5. A rope according to any of the preceding claims, **characterized** in that the input and the reception of the light pulse of the aforementioned optical fiber and/or fiber bundle (2) is at the same end of the aforementioned rope or in that the input and the reception of the light pulse of the aforementioned optical fiber and/or fiber bundle (2) are at opposite ends of the aforementioned rope.

6. A rope according to any of the preceding claims, **characterized** in that a single-mode or multimode fiber is used as the sensor fiber of the aforementioned optical fiber or fiber bundle (2) and the input of the light pulse occurs with a laser transmitter, preferably a semiconductor laser, or with a LED light source.

7. A rope according to any of the preceding claims, **characterized** in that the aforementioned optical fiber and/or fiber bundle (2) comprises a Fabry-Pérot-type sensor fiber.

8. A rope according to any of the preceding claims, **characterized** in that the aforementioned optical fiber and/or fiber bundle (2) comprises a sensor fiber, comprising a Bragg grating structure.

9. A rope according to any of the preceding claims, **characterized** in that the aforementioned optical fiber and/or fiber bundle (2) comprises a sensor fiber, which functions as a Brilloun distributed fiber sensor.

10. A rope according to any of the preceding claims, **characterized** in that the aforementioned optical fiber and/or fiber bundle (2) comprises a sensor fiber, in which fiber the time-of-flight of a light pulse is measured.

11. A rope arrangement (R) of a lifting device, more particularly of a passenger transport elevator and/or freight transport elevator, which rope arrangement comprises a plurality of ropes (10, 20, 30, 40, 50, 60,70, 80, 90, 100), which are arranged to move the elevator car (4) e.g. by the aid of a traction sheave (3), **characterized** in that at least one of the aforementioned ropes (10, 20, 30, 40, 50, 60, 70, 80, 90, 100), preferably all the ropes, are according to any of the preceding claims 1-10.

12. An elevator, preferably a passenger transport elevator and/or freight transport elevator, which comprises an elevator car (4), a traction sheave (3), a power source for rotating the traction sheave (3), **characterized** in that it comprises a rope (10, 20, 30, 40, 50, 60, 70, 80, 90, 100) according to any of claims 1-10 and/or a rope arrangement (R) according to claim 11, and in that the elevator car (4) is arranged to be moved by the aid of the aforementioned rope (10, 20, 30, 40, 50, 60, 70, 80, 90, 100) and/or rope arrangement (R).

13. An elevator according to claim 12, **characterized** in that the rope (10,20, 30, 40, 50, 60, 70, 80, 90, 100) and/or rope arrangement (R) is arranged to move an elevator car (4) and a counterweight (5).

14. An elevator according to any of the preceding claims 12-13, **characterized** in that the aforementioned rope (10, 20, 30, 40, 50, 60, 70, 80, 90, 100) is an overspeed governor rope and/or a compensating rope.

15. An elevator according to any of the preceding claims 12-14, **characterized** in that the elevator comprises means for monitoring the condition of the aforementioned optical fiber and/or a fiber bundle (2), which comprises a number of optical fibers, which means monitor the strain and/or displacement and/or condition of the aforementioned optical fiber and/or fiber bundle (2) from the load-bearing parts (11, 21, 31, 41, 51, 61, 71, 81, 91) of the rope.

16. A condition monitoring method for the rope of a lifting device, more particularly of a passenger transport elevator and/or freight transport elevator, **characterized** in that in the method the condition of a rope (10, 20, 30, 40, 50, 60, 70, 80, 90, 100) and/or roping (R) is monitored by monitoring the condition of an optical fiber and/or fiber bundle (2) and if it is detected that the strain and/or displacement of an optical fiber and/or fiber bundle (2) has increased and/or the condition of same has decreased over a certain pre-defined limit value, a need to replace or overhaul the rope or ropes is diagnosed and rope replacement work or rope maintenance work is started.

17. A method according to the preceding claim 16, **characterized** in that the rope (10, 20, 30, 40, 50, 60, 70, 80, 90, 100) is according to any of the preceding claims 1-10 and/or the rope arrangement (R) is according to claim 11.

18. A method according to any of the preceding claims 16-17, **characterized** in that a single-mode or multimode fiber is used as the sensor fiber of the aforementioned optical fiber or fiber bundle (2) and the input of the light pulse occurs with a laser transmitter, preferably a semiconductor laser, or with a LED light source.

19. A method according to any of the preceding claims 16-18, **characterized** in that the aforementioned optical fiber and/or fiber bundle (2) comprises a sensor fiber (2a) and a reference fiber (2b), with which in the method common mode errors, caused e.g. by changes in temperature, are eliminated.

20. A method according to any of the preceding claims 16-19, **characterized** in that the aforementioned optical fiber and/or fiber bundle (2) comprises a Fabry-Pérot-type sensor fiber, with which in the method e.g. the strain and/or displacement of the rope (10, 20, 30, 40, 50, 60, 70, 80, 90, 100) is measured.

21. A method according to any of the preceding claims 16-19, **characterized** in that the aforementioned optical fiber and/or fiber bundle (2) comprises a sensor fiber, comprising a Bragg grating structure, with which in the method e.g. the strain and/or displacement of the rope (10, 20, 30, 40, 50, 60, 70, 80, 90, 100) is measured.

22. A method according to any of the preceding claims 16-19, **characterized** in that the aforementioned optical fiber and/or fiber bundle (2) comprises a sensor fiber, which functions as a Brilloun distributed fiber sensor, with which in the method e.g. the strain and/or displacement of the rope (10, 20, 30, 40, 50, 60, 70, 80, 90, 100) is measured.

23. A method according to any of the preceding claims 16-19, **characterized** in that the aforementioned optical fiber and/or fiber bundle (2) comprises a sensor fiber, the time-of-flight of a light pulse in which fiber is measured, and with which in the method e.g. the strain and/or displacement of the rope (10, 20, 30, 40, 50, 60, 70, 80, 90, 100) is measured.

24. A method according to any of the preceding claims 16-23, **characterized** in that in the method the time-of-flight of a light pulse and/or e.g. strain are measured in a number of ropes (10, 20, 30, 40, 50, 60, 70, 80, 90, 100), when the measured values of which aforementioned ropes differ sufficiently from each other, a need to replace or overhaul the rope or ropes is diagnosed and rope replacement work or rope maintenance work is started.