

System and method for detecting the position of a lift cage

The present invention relates to a system and a method for detecting the position of a lift cage.

In order to move a lift cage in a lift shaft between different positions the cage is suspended at a flexible supporting and/or drive means. In most recent times belts, apart from conventional steel cables, have also established themselves as supporting and/or drive means, which belts, for example, couple the lift cage with the counterweight and/or transmit a traction force for raising and lowering the cage.

Knowledge of the position of the lift cage, thus its position in the lift shaft, is required for control of the cage. The speed or acceleration of the lift cage can also be determined from the position by differentiation according to time and can be similarly used in the control (for example the starting off or braking process or in the monitoring of a maximum speed / maximum acceleration), but also for, for example, determination of the actual cage total weight as a quotient of force, which is exerted on the cage by a drive means, and the resulting acceleration.

In order to determine the position of the lift cage, EP 1 278 693 B1 proposes a rotation transmitter which is arranged at the lift cage and which co-operates in mechanically positive manner with a separate cogged belt stretched in the shaft. This proposal requires, in disadvantageous manner, an additional cogged belt.

WO 2004/106208 A1 therefore proposes coding the support belt itself and detecting the position thereof by means of a detector arranged in the lift shaft. The codings shall, according to the specification, preferably be realised by a magnetic material embedded in the belt, by changes (particularly enlargements) of wires arranged in the belt or by an additional cable in the belt and shall be contactlessly detected by an appropriate detector. WO 2004/106209 A1 expressly advises against grooves in the belt due to noise problems.

In the detection of the coding, as is proposed in WO 2004/106209 A1, the belt not only moves in correspondence with the movement of a lift cage, but can additionally move relative to the detector due to longitudinal, transversal and/or torsional oscillations induced by, for example, system inertias, movements of the cage occupants or stick/slip effects in

the guidance of the lift cage. Such additional movements of the belt are falsely detected by the detector as positional changes of the lift cage and falsify the positional determination. These errors amplify when the speeds or even accelerations are determined from the positions.

A further disadvantage of the system known from WO 2004/106209 A1 consists in that the proposed detectors, particularly optical or magnetic systems, need electrical energy and thus are no longer functionally capable in the event of damage, for example a fire, so that it is no longer possible to safely move the lift cage, with its help, to a predetermined position (for example an emergency disembarking position at the next storey or the ground floor), for example through the lift being manually driven.

Finally, the systems proposed in WO 2004/106209 A1 are not optimal for the environmental conditions prevailing in a lift shaft, particularly contamination or wear of the belt, since on the one hand the magnetic or optical coding can be diminished and on the other hand the sensitive detectors necessary for detection thereof can be damaged.

Proceeding from WO 2004/106209 A1 it is therefore an object of the present invention to provide a system and a method for detection of the position of a lift cage which is not impaired or is impaired only slightly by oscillations of the belt.

For fulfilment of this object a system according to the introductory part of claim 1 is developed by the characterising features of claim 1. Claim 11 places the corresponding method under protection.

A system for detection of the position of a lift cage according to the present invention comprises a belt, at which the lift cage is suspended, and a detector for detection of the position of the belt. According to the invention the belt has on a first side a toothing in which a gearwheel of the detector mechanically positively engages.

Longitudinal oscillations in belt longitudinal direction, torsional oscillations about the belt longitudinal axis and transversal oscillations in the direction of the belt transverse axis thereby do not prejudice, or prejudice only slightly, the detected position of the belt, since on the one hand they are damped or even prevented by the mechanically positive engagement of the gearwheel in the toothing of the belt and on the other hand a relative

movement of the belt in a direction other than the rolling direction of the toothing, such as occurs with the aforesaid torsional or transversal oscillations, does not cause any change or causes only a slight change in the angular position of the gearwheel.

In addition, the mechanical, form-coupled measurement of the belt position by means of the gearwheel does not necessarily require electrical energy. A system according to a preferred embodiment of the present invention therefore allows determination of the belt position even in the case of energy failure, for example as a consequence of a fire situation, and thus enables manual controlling of the lift cage to an emergency disembarking position.

The gearwheel mechanically measuring the belt position can therefore be substantially more resistant relative to the environmental conditions prevailing in the lift shaft, particularly dirt, moisture and the like, than known optical or magnetic detectors. Beyond that it is also not disturbed by electrical or magnetic fields such as can occur, for example, in the vicinity of an electric motor lifting the lift cage. Moreover, changing light conditions, for example when switching on warning lamps in the lift shaft, do not, by contrast to optical systems, influence the positional detection by means of a gearwheel.

By "toothings" there is understood primarily an arrangement of alternating projections (teeth) and depressions (tooth gaps) which extend partly in the direction of the belt transverse axis, particularly straight, inclined, double or multiple toothings, wherein the individual projections and the toothings preferably complementary therewith in the toothing or the gearwheel can have, for example, a circularly segmental, cycloidal or involute cross-section. Such toothings, particularly helical toothings or toothings with involute or round teeth, can advantageously reduce the belt oscillations and noises occurring in operation. They can also make possible a particularly precise positional determination.

Preferably a tensioning element such as, for example, one or more guide rollers or a tensioner loaded by spring force can bias the belt against the gearwheel and thus ensure the mechanically positive engagement. Oscillations of the belt, which impair the positional determination, can thereby be further reduced or entirely suppressed.

The belt can comprise several cables or strands of singly or multiply twisted wires and/or synthetic material threads, which serve as tensile carriers and which are encased by a belt

body, for example of a resilient synthetic material. The toothing can in that case be constructed by primary forming of this synthetic material encasing. In a preferred development the synthetic material encasing can for this purpose comprise one or more layers, which have the toothing, of a different material, particularly of a different synthetic material, which is preferably hard, stable in shape and/or wear-resistant.

In a preferred embodiment the gearwheel is coupled with a rotation transmitter, particularly an incremental rotation transmitter or an angle coder, which issues a position signal corresponding with the absolute or relative angular position. A rotation transmitter for output of a position signal corresponding with the relative angular position can be constructed particularly simply, economically and/or robustly. The absolute position of the cage can also be indirectly determined with such a rotation transmitter by summing the complete revolutions.

Advantageously use can also be made of a rotation transmitter which directly indicates the absolute angular position, thus the number of (part) revolutions of the gearwheel from a zero position. Thus, for example, a strip wound up on the axle of the rotation transmitter can indicate the absolute position of the belt. Equally, the gearwheel can be coupled with the rotation transmitter by way of a speed step-up transmission so that a complete revolution of the rotation transmitter corresponds with several revolutions of the gearwheel. With particular advantage, the rotation transmitter can use a Gray coding. In a particularly preferred embodiment the rotation transmitter comprises a multi-turn rotation transmitter containing two or more code discs which each have one or more parallel code tracks and which are coupled together by way of a speed step-down transmission, in order to determine the absolute angular position.

The output of the absolute angular position has the advantage that no positions, in particular the previously executed complete revolutions of the gearwheel, have to be stored. Thus, for example, after a power failure the position of the belt can be directly determined by recognition of the absolute angular position without having to initially move again to a reference position.

Mixed forms are also possible in which, for example, the rotation transmitter indicates the position of the belt starting out from a respective storey, i.e., after movement of the cage by one storey, again indicates the same position. The absolute position of the belt or the

cage can then again be determined in a processing logic system by summation of the storeys covered. In the event of damage it can then be sufficient to determine the position of the cage relative to the closest storey door in order to securely move the cage to an emergency disembarking position.

A system according to the invention can further comprise a processing unit for determination of the position of the lift cage from the position signal. As explained in the foregoing, this can obtain the absolute or relative angular position from the rotation transmitter. Denoted as angular position in that case is the rotation modulo 2π executed by the gearwheel or rotation transmitter, whilst the absolute angular position denotes the entire rotation which is executed relative to a reference position and which therefore can also be a multiple of 2π .

For placing the system in operation this is preferably calibrated, wherein the processing unit stores, in particular, a reference position of the belt. Proceeding from this reference position the processing unit then determines a theoretical position of the lift cage from the absolute angular position of the rotation transmitter by multiplying this by, for example, the reference circle radius of the gearwheel. If the processing unit receives only a relative angular position, then it adds up the executed complete revolutions and adds this to the relative angular position before it again multiplies this sum by the reference circle radius of the gearwheel.

The belt can be articulated, i.e. fastened or deflected, to the lift cage in the form of, for example, a block-and-tackle with step-up or step-down translation so that a positional change of the belt does not directly correspond with a positional change of the lift cage. If, for example, the belt is articulated to the lift cage by way of a free roller, then the processing unit halves the position signal or the position change of the belt before it calculates therefrom the position of the lift cage in the shaft.

Apart from these systematic differences between the position of the belt and the lift cage still further deviations can occur if the belt, for example, stretches in longitudinal direction due to static or dynamic loads. In a preferred development the processing unit therefore comprises a correction unit for correction of the position signal. In this connection, for example, correction values which take into consideration the actual weight of the lift cage, the stretching of the belt occurring in that case or the like can be stored as tabular values.

If, for example, it is established by a device for detection of the actual cage weight that this corresponds with the maximum permissible total weight and it is known from tests or calculations that the belt then stretches by ~10% by comparison with the nominal weight then the correction unit corrects the theoretical cage position, which is determined by the processing unit on the basis of the angular position, by 10%.

Equally, a cage position determined by a further measuring device such as, for example, a contact switch, which is triggered by the lift cage, can also be taken into consideration in the correction of the positional determination. Thus, for example, the offset between the theoretical cage position, which is calculated on the basis of the position of the belt by the processing unit, and the actual cage position, which is detected by such a measuring device, which offset can result from, for example, stretching of the belt, can be detected in the correction unit and stored. The cage positions determined by the processing unit can subsequently be corrected by this stored offset, wherein advantageously this offset value is updated in each instance as soon as a new cage position has been detected by the further measuring device.

According to a preferred form of embodiment the belt has a second side which is remote from the first side and by way of which the belt is driven by a drive wheel or drive shaft by friction couple.

In a particularly preferred embodiment the belt has on its second side at least one wedge rib, which is oriented in belt longitudinal direction, or a planar surface, by way of which the belt is disposed in contact with the drive wheel or with the drive shaft. The same drive capability can advantageously thereby be realised with a lower belt tension. In the case of such lower belt tensions stronger belt oscillations arise which disadvantageously prejudice the positional determination with conventional detectors. The combination according to the invention of a toothing on the first belt side with wedge ribs on the second belt side does, however, permit determination of the position of the belt which, as explained in the foregoing, is less impaired by such belt oscillations. Advantageously such wedge ribs laterally guide the belt on the driving or deflecting wheels. Sideways movements of the belt are thereby prevented and a problem-free positional detection is made possible by the detector.

In a particularly preferred embodiment the toothing can be formed on a first side of a flat

belt opposite a second side which comes into engagement or contact with at least one driving and/or deflecting wheel. It is thus possible to realise a relatively wide toothing which is more insensitive with respect to displacements, which occur transversely to the toothing, relative to the gearwheel of the detector. In addition, the driving and/or deflecting wheels tighten the belt against the toothing and thus increase the reliability and precision of the tooth engagement.

Alternatively, the toothing can also be formed at a narrow side of the flat belt, which is preferably oriented approximately at right angles to a side coming into engagement with one or more driving and/or deflecting wheels. Since a flat belt is stiff in its transverse direction, due to the higher area moment of inertia, relative to bendings such a toothing can be more stable in shape so that deformations of the belt, which would prejudice the positional determination, are less.

Finally, the belt, which is preferably constructed as a flat belt, can also come into engagement or contact by its first side, which has the toothing, with at least one of the driving and/or deflecting wheels. The second side opposite the first side can, for reduction in the friction on deflecting wheels, be flat or similarly have a profile for guidance in driving or deflecting wheels, for example similarly have a toothing or one or more wedge ribs. The belt can come into engagement only by its first side, which has the toothing, or only by its second side opposite thereto, which preferably has wedge ribs, or by its first and second sides with one or more driving and/or deflecting wheels.

In a particularly preferred embodiment the belt always loops around an arrangement of deflecting and/or driving wheels by the same second side opposite the first side, so that its first side, which carries the toothing, does not come into contact with these deflecting and/or driving wheels. This preserves the toothing and thus increases the service life of the system.

The belt can, particularly for this purpose, be twisted about its longitudinal axis between two wheels of the arrangement of deflecting and/or driving wheels. If, for example, the belt loops around two successive wheels in the same plane, but in directions of opposite sense, the belt can be twisted through 180° about its longitudinal axis between these two wheels so that it loops around the two wheels by the same (second) side. If the axes of the two successive wheels are not, thereagainst, parallel, but, for example, oriented at

right angles to one another then the belt can be twisted through the appropriate angle, in this case thus 90°.

Deflecting wheels which, in particular, do not introduce tension forces into the belt, but only guide this, can also come into engagement with the first side, which is provided with the toothing, of the belt, since on the one hand the toothing is thereby hardly loaded, but on the other hand, particularly, for example, in the case of a double helical toothing, the belt is also sufficiently guided in transverse direction.

In an embodiment of the present invention the detector is arranged inertially fixed in a lift shaft in which the lift cage moves. This has the advantage that the position signals generated by the detector can be transmitted in simple manner to an inertially fixed lift control.

In the event of failure of the electrical energy supply a detector provided in accordance with the invention with a gearwheel, which mechanically positively co-operates with the belt and mechanically measures the position thereof, preferably also enables positional determination without electrical energy and thus a manually driven displacement of the cage to an emergency disembarking position. Thus, for example, in the event of power failure a drive wheel at the drive engine can, for evacuation of passengers, be manually rotated, whilst a detector, which also visually indicates the position, is observed. Such a detector preferably indicates the absolute position of the belt. Through observation of this detector it can be established, in the case of an evacuation, when the manually raised or lowered cage has reached a predetermined emergency disembarking position (for example, at the ground floor).

The gearwheel is preferably arranged in inertially fixed manner between a drive wheel and the suspension of the lift cage so that stretchings of the belt in the region of the counterweight do not impair the positional determination.

In another embodiment of the present invention the detector is arranged at the lift cage. Thus, the position can be made available directly in the lift cage. On the other hand, the belt is usually guided at the lift cage by one or more guide rollers, by which it can advantageously be biased against the gearwheel.

Further objects, advantages and features of the present invention are evident from the subclaims and the examples of embodiment described in the following. For this purpose:

Fig. 1 shows a lift installation with a system for detection of the position of a lift cage, according to a first embodiment of the present invention, in schematic form;

Fig. 2 shows a lift installation with a system for detection of the position of a lift cage, according to a second embodiment of the present invention, in an illustration corresponding with Fig. 1; and

Fig. 3 shows a section of a belt usable for detection of the position of the lift cage.

Fig. 1 shows a lift installation with a lift cage 1 vertically movable in a shaft 7. For raising and lowering the cage a belt 2 is fastened at one end thereof in the lift shaft (not illustrated) and runs from there over two deflecting wheels 5, which are arranged at the roof of the cage 1, and a drive wheel 4, which is driven by an electric motor (not illustrated), to a deflecting wheel at the counterweight 6.

The belt is constructed as a flat belt, in which several wire cables as tensile carriers are arranged in a belt body of polyurethane. It loops around the drive wheel 4 and the deflecting wheels 5 by a second flap side 2.2 (illustrated dark in Fig. 1). This has several wedge ribs which extend in belt longitudinal direction and which are in engagement with complementary grooves in the drive wheel 4 and the deflecting wheels 5. The belt tension can thereby be significantly reduced and at the same time a sufficient drive capability of the drive wheel 4 ensured.

Since the belt loops around the drive wheel 4 and the adjacent wheel 5 in opposite sense (in Fig. 1 the belt 2 is, going out from the counterweight 6, bent around the drive wheel 4 negatively in mathematical sense and around the adjacent deflecting wheel 5 positively in mathematical sense), the belt 2 is twisted about its longitudinal axis through 180° between these two wheels 4, 5 so that in each instance its second, flat side 2.2, which is provided with the wedge ribs, comes into engagement with the guide surfaces of the wheels 4, 5.

A toothing in which a gearwheel 3A of a detector (not illustrated) engages is formed on the

first flat side 2.1 (illustrated bright in Fig. 1), which is opposite the second flat side 2.2, of the belt 2. The gearwheel 3A is arranged inertially fixed in the lift shaft 7 in the vicinity of the drive wheel 4 so that the belt 2 is guided by the drive wheel 4 and the gearwheel 3A. If gearwheel and drive wheel are arranged sufficiently closely adjacent to one another, in particular separated only by a gap which substantially corresponds with the belt thickness, then the drive wheel advantageously presses the belt onto the drive wheel and thus prevents jumping-over of teeth, which improves the precision of the positional detection.

The gearwheel 3A is connected with a rotation transmitter (not illustrated) which determines the relative angular position of the gearwheel, i.e. the rotation modulo 2π thereof, and delivers a corresponding signal to a processing unit. This determines the absolute position of the belt 2 by adding the complete revolutions, which have already taken place, in correspondence with its sign (i.e. subtraction of revolutions in opposite sense) by multiplying the resulting total angle (relative angular position plus complete revolutions) by the reference circle radius of the gearwheel 3A. The processing unit subsequently halves this value for the purpose of consideration of the block-and-tackle arrangement of the belt 2 and determines therefrom the position of the cage 1 in the shaft 7.

Each time the cage 1 actuates a contact switch (not illustrated) arranged in the vicinity of the shaft door a correction unit detects this actual position of the cage 1 and compares with the theoretical value ascertained from the belt position. If the value ascertained from the belt position deviates - for example, due to belt stretching or a jumping-over of the toothing in the gearwheel 3A - from the thus-determined actual position of the cage 1 then the correction unit stores this deviation and subsequently adds it to the theoretical cage position determined from the gearwheel position.

Since the belt position is determined relatively precisely and with high resolution by the mechanical derivation it is possible to also precisely determine the speed or acceleration of the belt by simple or double differentiation over time, wherein, in particular, an unchanging belt extension can be left out of consideration. This allows monitoring of maximally occurring speed and acceleration values, running down of predetermined speed profiles and estimation of the cage total mass from the quotient of the tension force, which is exerted by the drive wheel 4 on the belt 2, and the resulting acceleration.

Fig. 2 shows a lift installation with a system for detecting the position of a lift cage according to a second embodiment of the present invention in an illustration corresponding with Fig. 1. The same elements are in that case provided with corresponding reference numerals, so that reference can be made to the preceding description for explanation thereof and only the differences from the first embodiment are discussed in the following.

In the second embodiment a gearwheel 3B is rotatably arranged at the carriage 1 and engages in the toothing on the first side 2.1 of the belt 2 in the vicinity of one deflecting wheel 5, so that the belt is additionally guided between deflecting wheel 5 and gearwheel 3B.

The gearwheel 3B is coupled by way of a step-down transmission with a rotation transmitter (not illustrated) in such a manner that a movement of the lift cage 1 between an uppermost and a lowermost maximum possible position, during which the gearwheel 3B executes several complete revolutions, just corresponds with a complete revolution of an encoding disc. Thus, the absolute angular position of the encoding disc directly reproduces the absolute position of the belt 2 from which, as in the case of the first embodiment, the position of the cage 1 can be determined.

Fig. 3 shows a section of the afore-described belt 2 serving as supporting and drive means for the lift cage as well as for detection of the position thereof. The belt has substantially the form of a flat belt. This has, on a first side 2.1, a toothing (10) with teeth which are oriented transversely to its longitudinal direction and in which - as illustrated in Figs. 1 and 2 - a gearwheel of the detector mechanically positively engages. The belt has on its second flat side 2.2 several wedge ribs 8 which extend in belt longitudinal direction and which come into engagement with complementary grooves in the drive wheel 4 and the deflecting wheels 5. Tensile carriers which are integrated in the belt body of the belt 2 and are preferably executed as wire cables or synthetic fibre cables are denoted by reference numeral 5. The tensile carriers are required because the strength of the belt body is not sufficient to transmit the tension forces arising in the belt.

Claims

1. System for detecting the position of a lift cage (1), with a belt (2) at which the lift cage is suspended and a detector for detecting the position of the belt, characterised in that the belt has on a first side (2.1) a toothing (10) in which a gearwheel (3A; 3B) of the detector mechanically positively engages.
2. System according to claim 1, characterised in that the gearwheel is coupled with a rotation transmitter which issues a position signal corresponding with the absolute or relative angular position.
3. System according to claim 2, characterised in that it further comprises a processing unit for determining the position of the lift cage from the position signal.
4. System according to claim 3, characterised in that the processing unit comprises a correction unit for correction of the position signal.
5. System according to any one of the preceding claims, characterised in that the belt (2) has a second side (3.2) which is remote from the first side (2.1) and by way of which the belt (2) is driven by a drive wheel (4) or a drive shaft by friction couple.
6. System according to claim 5, characterised in that the belt (2) has on the second side (2.2) remote from the first side one or more wedge ribs (8) or a planar surface, by way of which the belt (2) is disposed in contact with the drive wheel (4) or the drive shaft.
7. System according to any one of the preceding claims, characterised in that the belt loops around an arrangement of deflecting and/or drive wheels (4, 5) by the same side.
8. System according to claim 7, characterised in that the belt is twisted about its longitudinal axis, in particular through 180°, between two wheels of the arrangement of deflecting and/or drive wheels.
9. System according to any one of the preceding claims, characterised in that the detector is arranged to be inertially fixed in a lift shaft (7) in which the lift cage moves.

10. System according to any one of the preceding claims 1 to 8, characterised in that the detector is arranged at the lift cage.
11. Method for detecting the position of the lift cage (1) by means of a system according to any one of the preceding claims, comprising the steps of detecting the angular position of the gearwheel (3A, 3B) and determining the position of the lift cage from this angular position.