

Drive for a lift door with a displacement curve adapted to the air flows in the shaft

The invention relates to a method of operating a lift installation as well as to such a lift installation. The lift doors of the lift installation are actuated by a door drive by way of a travel curve.

Lift doors usually consist of a cage door, which is connected with a lift cage, and a plurality of shaft doors, which are arranged on storeys of a building and afford access to the shaft of the lift. On opening and closing, the cage doors and a shaft door are connected together by way of a coupling and moved in common by the door drive mounted on the lift cage.

Lift doors as used in, for example, high-speed lifts, have to meet various preconditions. Thus, shortest possible door closing times are desired by customers so as to achieve high levels of transport performance. EP 0 548 505 B1 discloses a method for rapid opening and closing of the lift doors in accordance with a travel curve. The travel curve contains data about duration and speed of the opening and closing of the lift doors as well as with respect to kinetic energy of the lift doors during these processes. Depending on the respective wind conditions prevailing in the shaft, the lift doors can close with greater or lesser expenditure of force and time, which impairs the transport performance.

US 3 822 767 A teaches detection of the wind speed prevailing in the shaft and a proportional adaptation of the magnitude of the closing force of the door drive, which moves the lift doors, to the strength of the wind speed prevailing in the shaft.

A travel curve, in fact, usually consists of several phases and, in particular, of an acceleration phase, a glide phase and a braking phase, wherein different closing forces prevail just in all three phases. In the acceleration phase and braking phase the lift doors are moved with high closing forces, but in the glide phase the lift doors are moved only with low closing forces. The travel curve is therefore not optimally matched to the pressure relationships, during opening and closing of the lift doors, through a proportional adaptation of the magnitude of the closing force of the door drive. Thus, an excessively rapid opening and closing of the lift doors causes an unnecessarily high consumption of electric power and leads to rapid wear of the lift doors, which in turn increases maintenance costs of the lift installation and also impairs serviceability of the lift

installation.

The object of the present invention is to provide a travel curve, which is optimal even under changing pressure relationships, for the opening and closing of lift doors. This object shall be realised with proven techniques of lift construction.

The object is fulfilled by the invention in accordance with the definition of the independent claims.

The invention teaches a method of operating a lift installation, as well as teaches a lift installation, with lift doors which are actuated in accordance with a travel curve. Pressure conditions and/or air flows are detected. A travel curve which is optimal with respect to the detected pressure relationships and/or air flows is determined from several travel curves. The advantage of the invention resides in the fact that the travel curve is optimally determined at all times, thus even in the case of unfavourable physical conditions, such as large pressure fluctuations and/or strong air draught, whereby the level of transport performance of the lift installation is impaired as little as possible.

Different travel curves are thus used for different pressure relationships and/or air flows. For example, a control of the door drive has at least two different travel curves for opening and closing the lift doors. One or other travel curve is used depending on the respective physical conditions.

Advantageously the pressure relationships and/or air flows are determined by measuring an air pressure and/or a temperature and/or a wind speed and/or further physical magnitudes in the shaft of the lift and/or on at least one storey. For example, for this purpose there is present in the shaft and/or on at least one storey a sensor unit which detects the physical conditions. In the case of use of several sensor units different pressure conditions and/or temperatures and/or wind speed and/or physical magnitudes can be detected at several regions in the shaft and/or between the shaft and the storeys. In addition, for example, meteorological data such as temperature and/or air pressure and/or wind speed are taken into consideration in the determination of the pressure relationships and/or air flows.

Advantageously the position and/or speed of further lift cages in the shaft is or are taken

into consideration for determination of the pressure relationships and/or air flows. For example the lift consists of a group of lift cages which are moved in an open shaft adjacent to one another and/or one above the other and which thereby produce in the shaft changing pressure relationships and/or air flows. The travel curve is optimal at any time through consideration of, inter alia, these unfavourable physical conditions.

Advantageously operational data of a building air conditioning plant and/or of a shaft ventilation are taken into consideration for determination of the air flow.

Building specific parameters such as, for example, the height of the building, the number of storeys, the quality of the building insulation, the number of open and/or closed entrances and windows, the kind of building roof, etc., are advantageously taken into consideration for determination of the pressure relationships and/or air flow.

In an advantageous refinement of the lift a target range is defined in which predefined pressure conditions and/or air flows prevail and in which a coupling of a lift cage door folds into the lift travel position prior to complete locking of a lift door. Thus, the coupling of the shaft door does not yet have to be separated after complete locking of the lift door.

In an advantageous embodiment of the lift a target range is defined in which the predefined pressure relationships and/or air flows prevail and in which departure of the lift cage is possible without the locking of the lift door being completely concluded. The lift cage thus leaves a storey before the lift doors are completely locked, which increases transport performance. For this purpose, for example, a coupling disposed between the cage door and the shaft door, as well as the door drive, are separately controlled in drive.

The invention is described in detail in the following on the basis of examples of embodiment and figures, in which:

Fig. 1 shows a schematic view of a first example of embodiment of a lift and a lift cage and different sensor units,

Fig. 2 shows a schematic view of a second example of embodiment of a lift with several lift cages and different sensor units,

- Fig. 3 shows a schematic view of an example of embodiment of an evaluating unit, which receives, from different sources, data about the physical conditions, for use in a lift according to Fig. 1 and/or Fig. 2,
- Figs 4A and 4B show schematic views of several examples of embodiment of travel curves for use in a lift according to Fig. 1 and/or Fig. 2 and
- Figs 5A and 5B show views of an example of embodiment of a lift door drive device with controllable coupling and door drive for use in a lift according to Fig. 1 and/or Fig. 2.

With regard to the lift and the lift cage: Fig. 1 shows a first form of embodiment of the lift installation, which is arranged in any building and comprises at least one lift cage 5. It can be any known lift installation 1 which has components such as a lift cage 5 for conveying persons and/or goods in a shaft 3 between storeys 2 of the building, as well as a drive for moving the lift cage 5 and a lift control 14 for controlling the drive.

With regard to the sensor unit: Under certain physical conditions strong air flows can occur in a shaft 3 and hinder movement and, in particular, closing of lift doors 4, 6. The circumstances under which such phenomena arise are complex. Through detection of, for example, the air pressure at different storeys 2 and/or at different positions in the shaft 3 it is possible to determine air flows in parts of the shaft 3 or even in the entire shaft 3. Further sensor units 10 to 12 can detect an air temperature and/or air flows at different locations in the shaft 3 and/or in the building. In addition, local meteorological data, such as temperature and/or air pressure and/or wind speed, can be used in the determination of the pressure relationships and/or air flows. Thus, in the case of a stormy weather forecast an appropriately adapted travel curve can be preventatively determined.

Fig. 1 shows different sensor units 10 to 12 which are arranged at various locations in the building. The sensor units 10 to 12 detect the most diverse physical conditions such as pressure relationships and/or air flows and/or the air pressure and/or temperature and/or wind speeds, etc. The sensor units 10 to 12 can in that case be commercially available units such as an air pressure sensor 10 (barometer), temperature sensor 11 (thermometer), wind speed sensor 12 (anemometer), etc.

There are various methods for measuring the air pressure. For example, the air pressure can be measured with the help of a pressure cell. This can either change its capacitance in dependence on the air pressure or deliver a voltage pulse by way of a piezo crystal. There are different commercially available models which function according to one of the two afore-mentioned forms of measuring. For example, the pressure sensors DC2R5BDC4 and DC010BDC4, both of Honeywell, can be used.

In the case of the temperature measurement, there are various methods for determining the temperature, for example with a resistance thermometer (thermometer with Pt100 sensor, for example W-10144 of Therma or 57101 of Wiesemann & Theis GmbH), or a semiconductor thermometer (thermometer with PTC sensor, for example B59011-C1080-A70 or B59011-C1040-A70 both of EPCOS. There are a number of commercially available models for both methods.

The measurement principle for the wind speed can be not only thermal, for example by wind cooling of a hot wire (for example ATA-30 of ATP Messtechnik GmbH), but also mechanical by measuring the volume flow. The most frequent principle for a wind speed measuring instrument is the cup anemometer or the hydrometric vane anemometer. The cup anemometer detects the wind speed in that a wind wheel of three or four hemispherical cups is driven by the wind, for example the cup anemometer WM30 of Vaisala. In the case of the hydrometric vane anemometer the wind speed sensor is equivalent to a ventilator (for example HGL-4018 of Heinz Hinkel Elektronik).

In the case of several lift cages: The example of embodiment according to Fig. 2 is substantially similar to that according to Fig. 1, so that reference is made to this description and differences with respect thereto are explained in the following. Fig. 2 shows several lift cages 5 in a shaft 3. In order to detect the numerous physical conditions in the case of several lift cages 5 in a shaft 3 the position and speed of each lift cage 5 in the shaft 3 is detected by sensors and/or by the lift control 14. Particularly in the case of a narrow shaft 3 and/or in the case of high speeds of the lift cages 5 the prevailing physical conditions are complex and pronounced.

Operational data of an air conditioning plant 16 or a shaft ventilation are taken into consideration as further physical conditions. It is assumed that not only the position of the

air inlet and air outlet, but also the operating power of the plant, have an influence on the physical conditions of the lift installation 1. It is conceivable that an emergency control such as, for example, a fire control of a building ventilation, is concomitantly taken into consideration.

With regard to the evaluating unit: The detected signals are communicated as data an evaluating unit 13. The sensor units 10 to 12 report the detected physical conditions as electrical analog or digital signals by way of connections, advantageously by way of a cable, for example, any building bus, or also by way of electromagnetic waves, for example radio 15, to an evaluating unit 13. Apart from the sensor units 10 to 12, the lift control 14 also communicates to the evaluating unit 13 data about number, position and speed of the lift cages 5 in the shaft 3.

The evaluating unit 13 evaluates these communicated data with respect to a travel curve, which is to be used, for opening and closing the lift doors 4, 6. Fig. 3 schematically shows an evaluating unit 13 which obtains data about the physical conditions from various sources and determines an optimum travel curve. The evaluating unit 13 is a commercially available device with, for example, inputs for the sensor units 10 to 12 and/or the lift control 14 and/or a building management system and/or an air conditioning plant 17 and/or a radio receiver 15 and/or an external network, for example an Internet 16. The evaluating unit 13 evaluates the data with the help of a processor and a software. The optimum travel curve can be determined by way of calculations on the basis of the physical conditions. In this case an infinite number of travel curves are available for the lift doors 4, 6. The optimum travel curve can, however, also be called up from a memory and thus be determined from a finite selection. The optimum travel curve is then communicated to the lift control 14. Lift control 14 and evaluating unit 13 can be disposed at different locations or at the same location. The evaluating unit 13 passes on this information to the lift control 14. Evaluating unit 13 and lift control 14 can also be realised in a single apparatus. In addition, it is possible to store the travel curve, which is to be used, in the lift control 14 and to communicate to the lift control 14 only information about the travel curve to be used.

Travel curves of the lift doors as a function of time: Figs 4A and 4B show several examples of embodiment of travel curves. A travel curve describes the opening and closing characteristic of the lift doors 4, 6. The lift doors 4, 6 consist of at least one cage

door 6 and, for each storey 2, at least one shaft door 4. The travel curve can be represented in different ways. Fig. 4A shows the speed during opening and closing of the lift doors 4, 6 as a function of time. Fig. 4B shows the power of door drive 22 during opening or closing of the lift doors 4, 6 as a function of time. The maximum speed which the lift doors 4, 6 attain can be dependent on the maximum value of the kinetic energy which the lift doors 4, 6 may reach for safety reasons. An optimum travel curve makes it possible for the lift control 14 to lock the lift doors 4, 6 as quickly as possible and to leave the storey 2 as quickly as possible, even in the case of unfavourable physical conditions. Apart from the physical conditions, also door drive 22, mass, door leaves, etc., play a role in determination of the optimum travel curve.

The closing time of the lift doors 4, 6 can be reduced by approximately 15 to 20% by an optimum travel curve. The time saved is dependent on the mass of the doors. Depending on the respective ratio of the motor torque and the mass, which is to be moved, of the lift doors 4, 6 this can vary by plus or minus 10%. This shortened door closing time accumulates in large buildings with many storeys 2. For example, for a typical journey of three stops with stop times of 8 seconds as well as travel times between two stops of 3 seconds ($3 \times 8 + 2 \times 3 = 34$ seconds) roughly 5% of time can be saved in the case of a saving of the door closing time of 0.6 seconds per closing process ($3 \times 0.6 = 1.8$ seconds).

A travel curve consists of three phases (I - III). In the acceleration phase (phase I) the lift doors 4, 6 are accelerated by a target power (P_{soll}) of the door drive 22 up to a target speed (v_{soll}). In Fig. 4A and Fig. 4B all curves (curves 1 - 4) are congruent in the acceleration phase.

In the glide phase (phase II) the lift doors 4, 6 are in movement, more or less without acceleration, at low drive power. In the case of the curve 1 the phase II with no drive power lasts the longest, since no unfavourable influences disturb the door closing process. In the case of the curve 2 through increase of the drive power up to the value of the target power (P_{soll}) the target speed (v_{soll}) can be kept to closely. The phase II thereby lasts just as long as in the case of the curve 1. In the case of the curve 3 notwithstanding increase in the drive power the target speed (v_{soll}) cannot be maintained. The phase II without acceleration is prematurely broken off by braking the lift doors 4, 6 due to unfavourable physical influences. In the case of the curve 4 the drive power is increased above the target power (P_{soll}) since it is known that unfavourable physical influences are responsible

for the resistance. The curve 4 is accordingly coincident in its closing time with the curves 1 and 2.

In the braking phase (phase III) the lift doors 4, 6 are braked again by the motor drive. In that case the curves 1, 2 and 4 have to be braked with equal strength, since their speed at the end of the phase II is always still v_{soll} . The curve 3 has a lower speed and thereby the door closing time is increased.

It is conceivable that the three phases occur more or less distinctly in a travel curve. In particular, the phase II may not even be present in the case of certain travel curves. In the case of an optimum travel curve an increased drive power can occur in the glide phase or even the braking phase.

The door drive 22 produces in the normal case (curve 1) the greatest power in terms of amount not only in the acceleration phase (I), but also in the braking phase (III) of the door closing. In addition, an increased drive power in the case of unfavourable physical conditions, for example in the case of poor pressure relationships or strong air flows, is required. In that case initially the drive power is regulated in correspondence with the poor physical conditions up to the maximum power (curve 2). If this maximum value is reached and the resistance to the cage door 6 rises further, then the speed of the cage door 6 slows down (curve 3).

The departure of the lift cage 5 takes place as soon as it is ensured that with the kinetic energy currently present in the lift doors 4, 6 and the available drive power of the door drive 22 a locking of the lift doors 4, 6 takes place in the time in which the coupling 21, as guide, has still not broken off the mechanical contact with the shaft door 4.

The evaluating unit 13 provides the calculated or stored travel curve. According to the travel curve of the evaluating unit 13 the lift control 14 reacts to unfavourable physical conditions by increasing the drive power in order to keep the door closing time to an optimum low value. Thus, without placing the safety of persons or things at risk the drive power can be increased above the target value (curve 4) since the cause for the increased power requirement resides in the unfavourable physical conditions and thus is known.

Coupling of a lift cage door: Figs. 5A and 5B show an example of embodiment of a lift

door drive device 20 with a coupling 21 of a cage door 6 to a shaft door 4. The coupling 21 can in that case be moved with the help of a coupling drive 24 by way of a coupling drive means 25 independently of the door drive 22 and the position of the lift doors 4, 6. Thus, in the case of optimum conditions the couplings 21 can already be folded into the lift travel position in order at the instant of locking of the lift doors 4, 6 to begin the departure of the lift cage 5 without delay. In the case of unfavourable external influences the coupling 21 remains mechanically connected with the shaft door 4 until this is locked and only then is folded into the lift travel position.

The length of the coupling 21 can be such that the departure of the lift cage 5 can already be begun before the lift doors 4, 6 are completely locked. Since the locking of the shaft door 4 and partly the cage door 6 is absolutely necessary for safety reasons the departure of the lift cage 5 can be commenced only if it is ensured that the lift doors 4, 6 are locked before the coupling 21, as guide, breaks off the mechanical contact with the lift doors 4, 6.

If a locking of the shaft door 4 up to the instant of the breaking-off of contact is not possible the lift cage 4 must be stopped by an emergency stop. In this case the shaft door 4 is moved into its locked state by the still present mechanical contact of the shaft door 4. It is conceivable that the guide length of the coupling 21 must thus be sufficient so as to be able to cover the travel path for the acceleration as well as also for a possible emergency stop of the premature departure. This means that a mechanical guide contact between coupling 21 and shaft door 4 must still be present. In that case the emergency stop can, depending on the respective stopping path available, take place with appropriately adapted acceleration. If the travel curve runs in sub-optimal manner this leads to a prolongation of the door closing times and/or reduction in the level of transport performance of the lift installation 1.

The drive control of the coupling 21 can take place in different ways; thus the coupling 21 can, for example, be provided with an own coupling drive 24 by way of a coupling drive means 25. It is also conceivable that the coupling 21 is directly mechanically connected with a door drive means 23 and thus is moved by the door drive 22.

Patent claims

1. Method of operating a lift installation (1), comprising, in combination, the steps of:
 - detecting of pressure relationships and/or air flows;
 - storing a plurality of travel curves in a memory of an elevator control;
 - determining an optimal travel curve for lift doors (4, 6) based upon the detected pressure relationships and/or air flows, selected from the plurality of travel curves; and
 - actuating the lift doors (4, 6) using the determined optimal travel curve.
2. Method according to claim 1, characterised in that the pressure relationships and/or air flows are determined by measuring
 - one or more of an air pressure, a temperature, a wind speed in the shaft (3) of the lift, and
 - by measuring on an at least one storey (2).
3. Method according to claim 1 or 2, characterised in that meteorological data such as temperature and/or air pressure and/or wind speed are taken into consideration in the step of detecting the pressure relationships and/or air flows.
4. Method according to any one of claims 1 to 3, characterised in that position and/or speed of at least one further lift cage (5) is or are taken into consideration in the step of detecting the pressure relationships and/or air flows.
5. Method according to any one of claims 1 to 4, characterised in that operating data of a building air conditioning plant (17) and/or a shaft ventilation are taken into consideration in the step of detecting the pressure relationships and/or air flows.
6. Method according to any one of claims 1 to 5, characterised in that at least one of the height of the building and further building-specific parameters are

taken into consideration in the step of detecting the pressure relationships and/or air flows.

7. Method according to any one of claims 1 to 6 wherein the step of actuating is accomplished by a door drive, and further comprising the step of moving a coupling (21) of a lift cage door (6) to the shaft door (4) independent of the door drive when the pressure relationships and/or air flows are within predetermined conditions.

8. Method according to any one of claims 1 to 7, characterised in that within a predefined target range of the pressure relationships and/air flows a lift cage (5) departs from a storey (2) before complete locking of the lift door (4, 6).

9. Method according to any one of claims 1 to 8, characterised in that a door drive power is readjusted in a braking phase of a lift door (4, 6) in order to reduce a door closing time.

10. Lift installation (1) comprising, in combination:
lift doors (4, 6);
a memory of an elevator control which stores a plurality of travel curves;
a door drive (22) for actuating the lift doors (4, 6) according to an optimal travel curve; and
at least one sensor unit (10 to 12) for detection of pressure relationships and/or air flows;
wherein an evaluation unit (13) selects the optimal travel curve for the lift door (4, 6) based upon the detected pressure relationships and/or air flows, from the plurality of travel curves.

11. Lift installation (1) according to claim 10, characterised in that the sensor unit (10 to 12) determines the pressure relationships and/or air flows by measuring

one or more of an air pressure, a temperature, a wind speed in the shaft (3) of the lift, and

by measuring on an at least one storey (2).

12. Lift installation (1) according to claim 10 or 11, characterised by communication from the elevator control (14) to the evaluating unit (13) of a position and/or speed of at least one further lift cage (5) in the determination of the pressure relationships and/or air flows.

13. Lift installation (1) according to any one of claims 10 to 12 wherein the coupling (21) of a lift cage door (6) to the shaft door (4) is moved independent of the door drive when the pressure relationships and/or air flows are within predetermined conditions.

14. An evaluating unit (13) comprising a processor and a software program, for carrying out the method according to any one of claims 1 to 9.