

(19)



(11)

EP 3 957 586 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

23.02.2022 Bulletin 2022/08

(51) International Patent Classification (IPC):

B66B 5/00 (2006.01) B66B 25/00 (2006.01)

(21) Application number: **20191425.6**

(52) Cooperative Patent Classification (CPC):

B66B 5/0037; B66B 25/006

(22) Date of filing: **18.08.2020**

(84) Designated Contracting States:

**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**

Designated Extension States:

BA ME

Designated Validation States:

KH MA MD TN

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(54) **A METHOD FOR LIFETIME ESTIMATION OF AN ELECTROMECHANICAL DEVICE IN AN ELEVATOR OR AN ESCALATOR OR A MOVING WALKWAY**

(57) The method comprises counting an actual number of working cycles C_{act} of the electromechanical device as a function of the time T , storing the actual number of working cycles C_{act} of the electromechanical device as a function of time T in a memory, calculating an expected lifetime L_{exp} of the electromechanical device

based on the actual number of working cycles C_{act} of the electromechanical device as a function of time by further considering a nominal number of working cycles C_{max_nom} of the electromechanical device, and storing the calculated expected lifetime L_{exp} of the electromechanical device in the memory.

EP 3 957 586 A1

Description

FIELD

[0001] The invention relates to a method for lifetime estimation of an electromechanical device in an elevator or an escalator or a moving walkway.

BACKGROUND

[0002] An elevator may comprise a car, a shaft, hoisting machinery, ropes, and a counterweight. A separate or an integrated car frame may surround the car.

[0003] The hoisting machinery may be positioned in the shaft or in a machine room above the shaft. The hoisting machinery may comprise a drive, an electric motor, a traction sheave, and a machinery brake. The hoisting machinery may move the car upwards and downwards in the shaft. The machinery brake may stop the rotation of the traction sheave and thereby the movement of the elevator car.

[0004] The car frame may be connected by the ropes via the traction sheave to the counterweight. The car frame may further be supported with guide means at guide rails extending in the vertical direction in the shaft. The guide rails may be attached with fastening brackets to the side wall structures in the shaft. The guide means keep the car in position in the horizontal plane when the car moves upwards and downwards in the shaft. The counterweight may be supported in a corresponding way on guide rails that are attached to the wall structure of the shaft.

[0005] The car may transport people and/or goods between the landings in the building. The shaft may be formed so that the wall structure is formed of solid walls or so that the wall structure is formed of an open steel structure.

[0006] Electromechanical devices, such as relays and contactors, are commonly used in various control circuits in elevators, escalators and moving walkways. The number of electromechanical devices has decreased in modern elevators, but the number is still considerable. Electromechanical devices are still used e.g. in different monitoring operations in elevators in which the number of working cycles of the relay may be very big. Electromechanical devices may be used in the door zones of an elevator to connect and disconnect current each time the car passes a landing. Electromechanical devices may also be used to connect and disconnect current before and after the car moves from one landing to another landing. Electromechanical devices may also be used in some special tasks in which the number of working cycles of the electromechanical device may be low. The activation of a rescue drive of the car with power provided from accumulators in case of a power failure may be activated via an electromechanical device. The emergency bottom in the car may activate an electromechanical device.

[0007] Electromechanical devices such as relays and

contactors are low cost devices, they are simple to control, and they provide galvanic isolation between the control circuit and the load circuit. Electromechanical devices have, however, a limited lifetime due to wear out. Problems in electromechanical devices are the most common reason for failure of the equipment. The lifetime of an entire electrical system can be forecasted accurately enough by the lifetime of the weakest part in the electrical system.

[0008] The main contactor of the drive is an important electromechanical device in an elevator. The main contactor must release at least each time when the direction of travel of the car changes. When the car stops, one does not normally know whether the next call requires the car to move upwards or downwards. The car should, however, start without a delay. The normal procedure is thus that the contactor is drawn before each drive and released after each drive. The opening of the contactor is also verified after each drive by monitoring that the rest position of the contactor and/or relay chain is realized. The number of working cycles of the contactors and/or relays is thus big being equal to the number of starts of the car.

[0009] More recent elevator codes, such as EN 81-20, support, in addition to safety solutions based on relays, also safety solutions based on programmable electronics (PESSRAL). This makes it possible to keep the supply network continuously connected to the lifting machinery via the elevator drive. There is no need to disconnect the power supply to the lifting machinery or the machinery brake. The removal of the torque rotating the motor and the closing of the machinery brake, acting as a safety component, may be realized and monitored with the aid of electronics. The contactor is thus not any more a safety component in the traditional meaning. The contactor may be used to disconnect the power supply in a fault situation or to prevent current from flowing to the load when the elevator is to be switched into a low current consumption state. This means that the drive may control its own contactor, i.e. the cut-off relay, more freely. The drive may control the contactor based on the frequency of the calls thereby trying to avoid unnecessary switching or when a drive request is received from the main control system.

[0010] This makes it possible to restrict the working cycles of the relays in the main current circuit, such as the main contactor or the cut-off relay, considerably and to prolong the lifetime of the relay measured by calendar time.

[0011] The elevators may be divided into different segments. The drives may be different in the different elevator segments. The lifetime of the drives may thus also be different. A first elevator segment may be formed by the high-rise elevators with high lifting heights and a high utilization rate. A second elevator segment may be formed by the mid-rise elevators used in lively environments e.g. office buildings, hotels, shopping centers and airports where the use of the capacity of the elevator is continuous, but the travel distances are short. A third

elevator segment may be formed of the low rise elevators used mainly in residential buildings where the traffic is concentrated to the morning and the afternoon and where the use of the elevator in the middle of the day and in the night is small.

[0012] The drive of the elevator is typically dimensioned for a lifetime of 10 to 15 years in normal use. There are, however, also elevators having a high degree of utilization, e.g. elevators on a metro station driving constantly day and night. The number of rides for such elevators may in 1 to 2 years reach the number of drives for a normal elevator in 10 years. There are on the other hand also elevators that are used very seldom.

[0013] The elevator subcomponents such as the drive must, in elevators being used heavily, be changed to a new one as a preventive measure before they fail i.e. long before other subcomponents in the control system must be changed. This is because other subcomponents are not in the same way exposed to wear. The calculated number of working cycles must be updated when a subcomponent is changed to a new one.

[0014] An unexpected failure while the elevator is in operation may cause a challenging situation. The unexpected failure may result in a situation in which passengers become entrapped in the car of the elevator between landings or a situation in which the elevator is put out of service. Both situations will cause a call out to the service center of the elevator.

[0015] A manual rescue operation may be integrated into the normal drive functionality of the elevator. The reason for this integration may be to reduce costs. A separate add on device for the manual rescue operation results in paralleling and doubling of electrical circuits and components as well as in additional mechanical enclosures and wiring. The costs will thus increase when using a separate add on device for the manual rescue operation.

[0016] An integrated solution leads, however, to a situation in which the normal operation of the elevator and the manual rescue operation share common parts e.g. common electromechanical devices. The functionality of the manual rescue operation becomes thus dependent on the reliability of multiple electromechanical devices in the drive.

[0017] One method for avoiding loss of operation due to failure in the devices in the electrical system, is to duplicate at least those main parts in the electric system that are subject to wear out. The rescue operation is thus switched to be performed by a separate circuit and/or by separate components compared to the normal operation. This approach requires changeover circuits to be used which involve additional technical challenges. This approach involves also increased costs due to the use duplicated parts.

[0018] A sudden and unexpected wear out of an electromechanical device shared by the normal operation and the rescue operation will prevent any operation of the elevator. This is naturally a situation which should be

avoided.

[0019] The condition of the battery must be monitored in a battery powered drive apparatus integrated into the elevator. This may be done by testing the battery at regular intervals by first discharging and then charging the battery to determine the load endurance and charging capacity of the battery. The electromechanical devices operated in these battery tests will thus be subject to additional working cycles. The additional working cycles must be taken into consideration when determining the lifetime of the electromechanical devices. A battery test may be done approximately once a month. The number of test cycles may in fact be greater than the number of actual working cycles of the electromechanical device in countries where power failures are rare events. The situation may on the other hand be reversed in countries in which power failures are very frequent events.

[0020] Lifetime testing of electromechanical devices such as relays and contactors may be carried out by the manufacturer during the development of the electromechanical device based on a typical or a worst-case use working cycle. The tests may be performed with accelerated cycling, higher duty ratios, shorter sequence times, a higher ambient temperature, and an increased humidity in order to get results fast enough.

[0021] The results of accelerated lifetime testing of the electromechanical device might not fully follow the aging of the electromechanical device in real use in field conditions. The results of the accelerated lifetime testing do, however, give a rough understanding of the worst-case lifetime expectancy.

[0022] Electromechanical devices are often replaced according to a fixed predetermined replacement period. The replacement is often done well in advance i.e. long before the end of the nominal estimated lifetime of the electromechanical device. A rather big safety margin for the replacement is used to be sure that the electromechanical devices are replaced before the actual failure occurs.

[0023] The electromechanical devices are often the most critical devices in the electrical system in view of the estimated lifetime as other parts of the electrical system often comprise solid-state circuits. Wear out of solid-state circuits before the end of their lifetime is rather unlikely, although other functional problems may naturally occur also in solid state circuits.

[0024] An electromechanical device may comprise at least one electromagnet and at least one movable contact. The at least one movable contact may form a switch in an electric circuit so that the electric circuit is open when the contact is open and vice a versa. The at least one movable contact may be operated by the electromagnet. The electromagnetic device releases when the current to the electromagnet is cut and draws when the current to the electromagnet is connected.

SUMMARY

[0025] The inventive method solves or reduces the problems relating to prior art methods for estimating the lifetime of an electromechanical device in an elevator or an escalator or a moving walkway.

[0026] The inventive method is defined in claim 1.

[0027] The inventive method comprises counting an actual number of working cycles C_{act} of the electromechanical device as a function of time T , storing the actual number of working cycles C_{act} of the electromechanical device as a function of time T in a memory, calculating an expected lifetime L_{exp} of the electromechanical device based on the actual number of working cycles C_{act} of the electromechanical device as a function of time T by further considering a nominal number of working cycles C_{max_nom} of the electromechanical device, storing the calculated expected lifetime L_{exp} of the electromechanical device in the memory.

[0028] The inventive method makes it possible to determine the expected lifetime of an electromechanical device in a more reliable and precise way compared to prior art methods. The method may be used to determine an expected lifetime for all or for a part of the electromechanical devices in an elevator or escalator. The method may be especially useful in situations in which the same electromechanical device is used in a normal operation and in a rescue operation of the elevator. The risk of a failed electromechanical device preventing normal use of the elevator or escalator as well as rescue use of the elevator will thus be reduced.

[0029] The inventive method makes it possible to predict aging of electromechanical devices in a more precise way. The replacement of the electromechanical devices can thus be done at an optimal time. The optimal time to replace an electromechanical device is just before the electromechanical device fails. The inventive method makes it possible to use the electromechanical devices longer without increasing the risk for a sudden and unexpected brake down of the electromechanical device. The maintenance of the electromechanical devices becomes easier and extraordinary service visits may be avoided. The replacement of the electromechanical devices may be done in connection with a planned visit to the site.

[0030] The inventive method may be applied so that each critical electromechanical device in the installation is monitored separately. This may be an advantageous solution in case the number of working cycles of each electromechanical device in the installation is different.

[0031] The inventive method may on the other hand be applied so that a group of critical electromechanical devices in the installation are monitored on a common basis. This may be an advantageous solution in case the number of working cycles of each electromechanical device in the installation is equal or substantially equal.

[0032] The manufacture of the electromechanical device may provide data for two types of working cycles of the electromechanical device. The manufacture may provide a mechanical nominal number of working cycles for the electromechanical device and/or an electrical nominal number of working cycles for the electromechanical device.

[0033] The electrical nominal number of working cycles of the electromechanical device may be measured by the manufacturer in an accelerated test where a resistive load with a nominal voltage and a nominal current is applied to the electromechanical device.

[0034] The mechanical nominal number of working cycles for an electromechanical device may be measured by the manufacturer in an accelerated test in which the electromechanical device is switched mechanically, i.e. no load, no voltage and no current is applied to the electromechanical device. The mechanical nominal number of working cycles of an electromechanical device is normally much greater than the electrical nominal number of working cycles of the electromechanical device.

[0035] The electromechanical devices are seldom used with a resistive load. The loads connected to the electromechanical devices are usually at least to some extent inductive or capacitive. Electromechanical devices are normally used in elevators so that the electromechanical device does not connect or disconnect the maximum load current. The load current is activated after the connection of the electromechanical device and the load current is disconnected before the disconnection of the electromechanical device. The electromechanical device is thus usually subject to a smaller load current compared to the load current used in the lifetime test performed by the manufacturer. The electromechanical devices in an elevator or an escalator may have to connect a capacitive load and to disconnect an inductive load, which is against the recommendations of the manufactures of the electromechanical devices. Lifetime data provided by the manufactures of the electromechanical devices are thus not useful in elevator or escalator applications.

[0036] Drives with different powers and differences in the used components may be connected to a single control system of an elevator. The counting of the working cycles may thus be realized as a part of the component to be monitored. When a drive is changed to a new one the counters of the new drive begin from zero. The counters may be included as a part in the control system so that a common communication bus transfers information between the control system and the subcomponent such as between the elevator control system and the drive. This may be realized so that the component itself takes care of the calculation of the lifetime of the subcomponent based on the number of working cycles and the measured environmental parameters influencing the lifetime. The calculation data will thus follow the component to be changed. The sensor data and the number of working cycles needed to be able to perform the calcu-

lation in the control system may be received from the subcomponent.

[0037] The number of working cycles of the electromechanical devices i.e. the relays and the contactors in the drives may not be directly proportional to the number of starts of the elevator. The relay working as the main contactor may not be switched in each start. The system comprises also other more seldom used relays having quite different working cycles compared to the working cycles of the relays in the main circuit.

[0038] A working cycle of an electromechanical device may be defined as the action of opening and closing the contacts of the electromechanical device.

DRAWINGS

[0039] The invention will in the following be described in greater detail by means of preferred embodiments with reference to the attached drawings, in which

Figure 1 shows a side view of an elevator,
Figure 2 shows a lifetime estimation sequence diagram for an electromechanical device.

DETAILED DESCRIPTION

[0040] Fig. 1 shows a side view of an elevator.

[0041] The elevator may comprise a car 10, an elevator shaft 20, hoisting machinery 30, ropes 42, and a counterweight 41. A separate or an integrated car frame 11 may surround the car 10.

[0042] The hoisting machinery 30 may be positioned in the shaft 20 or in a machine room above the shaft. The hoisting machinery may comprise a drive 31, an electric motor 32, a traction sheave 33, and a machinery brake 34. The hoisting machinery 30 may move the car 10 in a vertical direction Z upwards and downwards in the vertically extending elevator shaft 20. The machinery brake 34 may stop the rotation of the traction sheave 33 and thereby the movement of the elevator car 10.

[0043] The car frame 11 may be connected by the ropes 42 via the traction sheave 33 to the counterweight 41. The car frame 11 may further be supported with guide means 27 at guide rails 25 extending in the vertical direction in the shaft 20. The guide means 27 may comprise rolls rolling on the guide rails 25 or gliding shoes gliding on the guide rails 25 when the car 10 is moving upwards and downwards in the elevator shaft 20. The guide rails 25 may be attached with fastening brackets 26 to the side wall structures 21 in the elevator shaft 20. The guide means 27 keep the car 10 in position in the horizontal plane when the car 10 moves upwards and downwards in the elevator shaft 20. The counterweight 41 may be supported in a corresponding way on guide rails that are attached to the wall structure 21 of the shaft 20.

[0044] A main controller 100 may be used to control the elevator. The control of the elevator may be distributed. The master part of the control system, i.e. the part

providing the calls in the system, may be positioned at the bottom floor of the building. The elevator inverter in the drive 31 driving the electric motor 32 may on the other hand be positioned near the lifting machinery 30 in the shaft 20 at the top floor of the building or in a separate machinery room above the top floor of the building.

[0045] The car 10 may transport people and/or goods between the landings in the building. The elevator shaft 20 may be formed so that the wall structure 21 is formed of solid walls or so that the wall structure 21 is formed of an open steel structure.

[0046] Figure 2 shows a lifetime estimation sequence diagram for an electromechanical device.

[0047] The method for estimating the lifetime of an electromechanical device may be realized in the following way.

[0048] Step 501 comprises counting the actual number C_{act} of working cycles of the electromechanical device.

[0049] The counting may be performed by a controller of the elevator or escalator or by a separate counter formed of a simply electronic circuit.

[0050] Step 502 comprises storing the actual number C_{act} of working cycles of the electromechanical device in a memory.

[0051] Step 503 comprises calculating an expected lifetime L_{exp} of the electromechanical device.

[0052] The expected lifetime L_{exp} of the electromechanical device may be calculated based on the actual number C_{act} of working cycles of the electromechanical device and based on the nominal number C_{max_nom} of working cycles of the electromechanical device. The nominal number C_{max_nom} of working cycles of the electromechanical device may be a result of accelerated lifetime testing of the electromechanical device.

[0053] Step 504 comprises storing the expected lifetime L_{exp} of the electromechanical device in the memory.

[0054] A moving average for the expected lifetime L_{exp} of the electromechanical device may further be calculated based on a subset of the calculated expected lifetime values L_{exp} that have been stored in the memory. A moving average is a calculation to analyze data points by creating a series of averages of different subsets of the full data sets. The moving average could e.g. be a simple moving average or a cumulative moving average or a weighted moving average.

[0055] It can be assumed, based on experience and literature, that only a limited number of parameters have a significant influence on the expected lifetime of an electromechanical device. These parameters relate basically to the conditions on the site of the elevator or escalator. The parameters are
the ambient temperature on the site,
the (relative) humidity level on the site,
the actual number of working cycles of the electromechanical device on the site.

[0056] An equation for calculating the expected lifetime of an electromechanical device may thus be defined in the following way:

$$L_{exp} = \frac{C_{max_nom}}{\frac{C_{act}}{T}} * X_{temp} * X_{hum}$$

where

L_{exp} denotes the expected lifetime of the electromechanical device.

C_{max_nom} denotes the nominal number of working cycles of the electromechanical device. This value may be based on the results of accelerated lifetime tests.

C_{act}/T denotes the actual number of working cycles in time recorded by the control system of the elevator or escalator.

X_{temp} denotes a temperature dependent aging parameter of the electromechanical device. This value may be based on the results of accelerated lifetime tests.

X_{hum} denotes a humidity dependent aging parameter of the electromechanical device. This value may be based on the results of accelerated lifetime tests.

[0057] Sensors may be used to measure the ambient temperature and/or the humidity on the actual site of the elevator or escalator. The control system of the elevator or escalator may be used to calculate average values of the measured ambient temperature and/or of the humidity values. The number of working cycles of the electromechanical device may be calculated by the controller of the elevator or escalator or by a separate counter, e.g. an electronic counter circuit. The expected lifetime equation may thereafter be used for estimating the remaining lifetime of the electromechanical device.

[0058] The remaining lifetime may be indicated by a value showing the number of working cycles that are left or by a value showing the lifetime that is left. The expected lifetime calculation may be executed each time when the electromechanical device performs a new working cycle. The expected lifetime calculation may be stored in a memory in the control system of the elevator or the escalator. Any programmable memory e.g. an eeprom may be used for storing the information.

[0059] An elevator or an escalator may be provided with a remote connection to a remote monitoring service. The remote monitoring service may be in the form of an external device and/or a remote-control center and/or a cloud service. The key parameters related to the aging of the electromechanical device may in such case be transmitted from the elevator to said remote monitoring service. The key parameters may be the actual number of working cycles of the electromechanical device, the humidity on the site, and the temperature on the site. The calculations of the expected remaining lifetime for a specific electromechanical device and/or for an entire population of similar electromechanical devices on the field may be made in the remote monitoring service. The re-

mote monitoring service may on the other hand transmit updated data relating to the parameters used in the expected lifetime calculation to the elevator.

[0060] An elevator or an escalator may on the other hand not be provided with a connection to a remote monitoring service. A warning diagnostic code may in such case be sent to the user interface of the elevator or escalator showing the remaining lifetime of the electromechanical devices. The remaining lifetime could be shown in suitable steps of e.g. +5%. The user interface could show e.g. "75% of lifetime reached" followed by "85% of lifetime reached", etc. The value of the remaining lifetime could be shown under a dedicated user interface parameter value before the warning level is reached.

[0061] The accelerated wear out testing of the electromechanical device may be done by applying a low use working cycle and a high use working cycle or even by applying three different types of working cycles. The number of working cycles before failure of the electromechanical device will probably be different in the three different types of working cycle tests. The result received in the test being closest to the actual situation on the site could then be used in the equation for estimating the expected lifetime of the electromechanical device. This may further increase the accuracy of the calculation of the expected lifetime of the electromechanical device.

[0062] Practical experience of failed equipment after reaching the calculated failure point, despite the warning message, or after exceeding the 100% limit of the calculated lifetime may be used to improve the equation for the lifetime estimate. Equipment failure can be made to happen e.g. in the in-house elevator or escalator testing.

[0063] The same results can be reached by a significant population of non-failed units on field, giving higher confidence level for the calculation.

[0064] The temperature dependent aging parameter X_{temp} and the humidity dependent aging parameter X_{hum} of the electromechanical device may not be provided by the manufacturer of the electromechanical device. The manufactures typically provide values for the electrical lifetime of the electromechanical device as a nominal number of electrical working cycles measured with a resistive load at nominal voltage and nominal current. The manufactures also typically provided values for the mechanical lifetime of the electromechanical device as a nominal number of mechanical working cycles.

[0065] The temperature affects electromechanical devices so that the resistance of the contact in the electromechanical device increases when the temperature increases. An increased temperature may also cause deformations in the electromechanical device because different materials in the electromechanical device have different coefficients of thermal expansion. The temperature in combination with the humidity may cause deformation of the plastic parts and corrosion on the contacts. A strong vibration is problematic because it may cause the contacts of the electromechanical device to change state especially in case the relay is light. The contacts in

the electromechanical device are thus subject to extraordinary arcing.

[0066] The master portion of the control system of an elevator may be positioned in a bottom floor of the building and the elevator drive is normally positioned near the hoisting machinery in the shaft at the top floor of the building or in a machine room above the topmost floor of the building. The walls in the shaft may be of glass in some buildings. This means that an elevator drive positioned in the shaft at the topmost floor in the building may be exposed to direct sunshine. The temperature of the elevator drive may thus be quite different compared to the temperature of the master portion of the control system. The temperature must thus be measured locally at the elevator drive. The elevator drive comprises hot components so that the temperature within the drive may be 10 to 20 degrees Celsius above the temperature of the environment during the driving of the car. The elevator drive may be attached to the guide rail of the elevator in the shaft. The vibration of the drive attached to the guide rail will be higher compared to a drive attached to a wall in the bottom floor or to a wall in the machine room positioned above the topmost floor in the building.

[0067] The invention may be realized so that the parameters affecting the lifetime of the electromechanical device are determined in long-term accelerated lifetime tests. Electromechanical devices of different manufacturers may be aged in different environmental conditions to determine the parameters affecting the lifetime of the electromechanical device based on the differences in the reached working cycles. The calculation of the expected lifetime may be tied to the used number of working cycles. The value of the parameters may in a first step when the elevator or escalator has been installed be replaced with the number 1 in the calculation. A more precise value of the parameters may then later be updated in connection with firmware updates or parameter updates. The more precise parameter values may be determined when the conditions on the site have been determined. The temperature, the humidity and actual number of working cycles of the electromechanical device are measured and updated continuously on the site. The measured values may be stored and continuously updated into the memory of the subcomponent or the sub control system.

[0068] An experimental accelerated lifetime test gives more reliable information of the number of working cycles of the electromechanical device before failure compared to the data received from the manufacturer of the electromechanical device. The experimental lifetime test may be conducted so that the load of the electromechanical device and the control of the electromechanical device is more precisely related to the real conditions of the electromechanical device.

[0069] An accelerated expected lifetime test should be performed so that the overall time used for the test is rather fast. The aging of the electromechanical device should on the other hand correspond to the aging of the electromechanical device in real circumstances on the

site. The aging of the electromechanical device may, in an accelerated test, differ from the aging of the electromechanical device in real circumstances on the site due to an excess stress in the accelerated test. The working cycle plays a role in this. The relation between the duration of the load phase and the duration of the rest phase may be big i.e. the cooling time becomes short and leads to an unrealistic increase in temperature. A long duration of the working phase may thus shorten the lifetime of the electromechanical device compared to the lifetime of an electromechanical device being subjected to the same number of working cycles but with longer rest phases.

[0070] The conditions on the site such as the air pollution and the salinity in the air near shores may influence the expected lifetime of the electromechanical device. These environmental conditions may accelerate the corrosion of the parts of the electromechanical device. In case the geographical position of the elevator is stored as a parameter in the control system of the elevator, it may be possible to further improve the calculation of the expected lifetime of the electromechanical device by taking into account still further parameters.

[0071] These further parameters may be included into the temperature and humidity parameters in the formula for calculating the expected lifetime of the electromechanical device. There is thus no need to include such further parameters as separate parameters in the formula.

[0072] It may be possible to determine further parameters affecting the aging of the electromechanical device e.g. in cyclic humidity and temperature tests and air pollutions may be simulated with a salt spraying test.

[0073] The use of the invention is not limited to the elevator disclosed in the figures. The invention can be used in any type of elevator e.g. an elevator comprising a machine room or lacking a machine room, an elevator comprising a counterweight or lacking a counterweight. The counterweight could be positioned on either side wall or on both side walls or on the back wall of the elevator shaft. The drive, the motor, the traction sheave, and the machine brake could be positioned in a machine room or somewhere in the elevator shaft. The car guide rails could be positioned on opposite side walls of the shaft or on a back wall of the shaft in a so-called ruck-sack elevator.

[0074] The invention may advantageously be used in elevators. The invention may, however, also be used in escalators and in moving walkways.

[0075] It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can be implemented in various ways. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.

Claims

1. A method for lifetime estimation of an electromechanical device in an elevator or an escalator or a moving walkway, the method comprising
 counting an actual number of working cycles C_{act} of the electromechanical device as a function of time T,
 storing the actual number of working cycles C_{act} of the electromechanical device as a function of time T in a memory,
 calculating an expected lifetime L_{exp} of the electromechanical device based on the actual number of working cycles C_{act} of the electromechanical device as a function of time T by further considering a nominal number of working cycles C_{max_nom} of the electromechanical device,
 storing the calculated expected lifetime L_{exp} of the electromechanical device in the memory.
2. The method according to claim 1, wherein a temperature dependent aging parameter X_{temp} of the electromechanical device is further considered when the expected lifetime L_{exp} is calculated.
3. The method according to claim 1 or 2, wherein a humidity dependent aging parameter X_{hum} of the electromechanical device is further considered when the expected lifetime L_{exp} is calculated.
4. The method according to any one of claims 1 to 3, wherein environmental conditions on the site of the electromechanical device such as air pollution and/or salinity in the air is further considered when the expected lifetime L_{exp} is calculated.
5. The method according to any one of claims 1 to 4, wherein the calculation of the expected lifetime L_{exp} of the electromechanical device is executed each time when the actual number of working cycles C_{act} of the electromechanical device increases.
6. The method according to claim 5, wherein the expected lifetime L_{exp} of the electromechanical device is determined as a moving average of a subset of calculated expected lifetime L_{exp} values.
7. The method according to claim 1, wherein the expected lifetime L_{exp} is calculated by the following equation

$$L_{exp} = \frac{C_{max_nom}}{\frac{C_{act}}{T}} * X_{temp} * X_{hum}$$

where

L_{exp} denotes the expected lifetime of the electromechanical device,

C_{max_nom} denotes the nominal number of working cycles of the electromechanical device,

C_{act}/T denotes the actual number of working cycles during a time period T of the electromechanical device,

X_{temp} denotes a temperature dependent aging parameter of the electromechanical device,

X_{hum} denotes a humidity dependent aging parameter of the electromechanical device.

8. The method according to claim 7, wherein the value of the temperature dependent aging parameter X_{temp} and the humidity dependent aging parameter X_{hum} of the electromechanical device are set to 1 when the elevator or the escalator is taken into use for the first time.
9. The method according to claim 7, wherein the value of the temperature dependent aging parameter X_{temp} and the humidity dependent aging parameter X_{hum} of the electromechanical device are adjusted when more accurate information of the actual number of working cycles, the temperature and the humidity on the site of the electromechanical device are available.
10. The method according to any one of claims 1 to 9, wherein the nominal number of working cycles C_{max_nom} of the electromechanical device is determined in accelerated lifetime tests of the electromechanical device.
11. The method according to claim 10, wherein the accelerated lifetime tests are performed in conditions simulating the actual working conditions of the electromechanical device.
12. The method according to any one of claims 1 to 11, wherein the calculated expected lifetime L_{exp} of the electromechanical device is transmitted to a remote monitoring service.
13. The method according to any one of claims 1 to 12, wherein parameter information for the calculation of the expected lifetime L_{exp} of the electromechanical device is transmitted from a remote monitoring service to the elevator.
14. A computer program product comprising program instructions, which, when run on a computer, causes the computer to perform a method as claimed in any of claims 1-13.

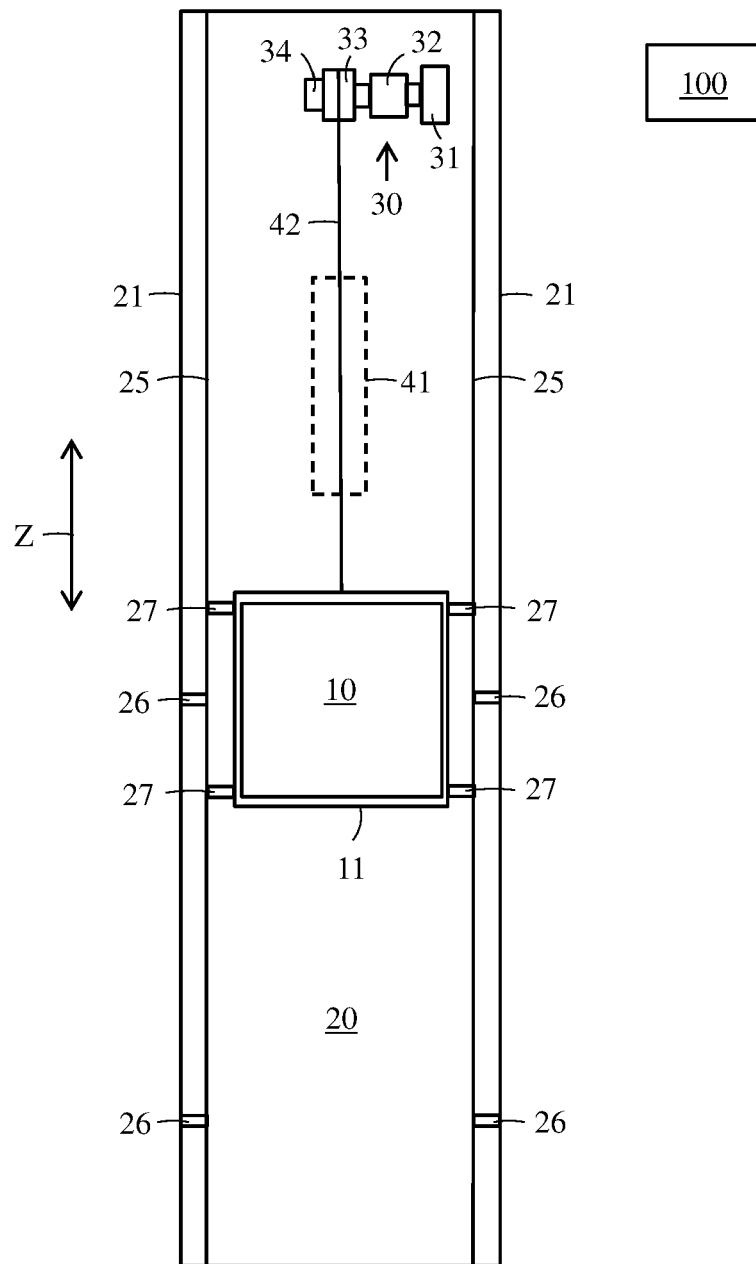


FIG. 1

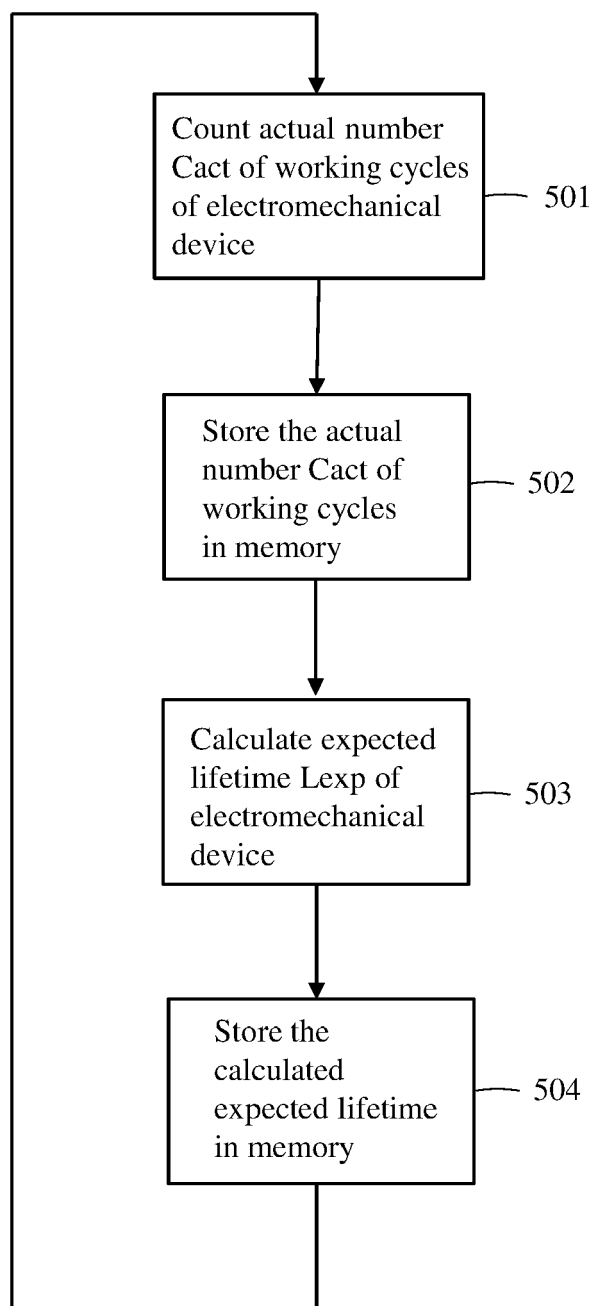


FIG. 2



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Application Number
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 26 January 2021	Examiner Severens, Gert
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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