

ELEVATOR ABNORMALITY DETECTION DEVICE AND ELEVATOR ABNORMALITY DETECTION METHOD

BACKGROUND

1. Technical Field

[0001]

The embodiments of the present invention relate to an elevator abnormality detection device and an elevator abnormality detection method.

2. Related Art

[0002]

An elevator device includes an inverter power supply to drive a hoist motor that raises and lowers a cage and an opening/closing motor that opens and closes a door of the cage. When the inverter power supply becomes overheated, the semiconductors and the like that constitute the inverter power supply may suffer damage. Therefore, the inverter power supply is often cooled by forced air cooling.

[0003]

As the elevator device becomes larger in size, the output power of the inverter power supply required increases, and accordingly, the amount of heat generated by the inverter power supply also increases. If the cooling effect of forced air cooling is not sufficient, a water-cooled cooling system may be used to cool the inverter power supply.

[0004]

For example, the water-cooled cooling system cools the inverter power supply by passing a pipe through a heat sink used to cool switching elements (semiconductors) of the inverter power supply and passing water through the pipe. Water in the pipe is caused to flow by a pump and cooled through heat radiation by a radiator.

[0005]

In the case of forced air cooling, only a fan motor for blowing is used as a cooling system. When the fan motor for blowing is stopped, the temperature of switching elements (semiconductors) of the inverter power supply rises rapidly. Therefore, by installing a temperature sensor near the switching elements of the inverter power supply, it is possible to identify a cause of damage of the cooling system.

Prior Art Document

Patent Document

[0006]

Patent Document 1: JP-A-2019-151437

[0007]

On the other hand, the water-cooled cooling system is constituted of a plurality of parts, such as a pipe, a tank, a pump, and a radiator. The causes of damage of the water-cooled cooling system are complex and include, for example, cracks in the pipes, stops of the radiator fan, and a decrease in the drive power of the pump. The degree of decline in the cooling effect also varies. Therefore, in the case of a water-cooled cooling system, it is difficult to identify the cause of damage.

[0008]

The present invention has been made in consideration of the above-described circumstance, and an object of the present invention is to identify a cause of damage of a water-cooled cooling system used in an elevator device.

SUMMARY

[0009]

The elevator abnormality detection device according to embodiments to achieve

the above object is an elevator abnormality detection device that detects an abnormality in a water-cooled cooling system that cools a power supply that supplies power to a motor that drives ascent and descent of a cage. The elevator abnormality detection device according to the embodiments includes a temperature sensor, a storage unit, and an abnormality detecting unit. The temperature sensor measures a temperature of a heating element constituting the power supply when the cage performs an ascent or descent operation. The storage unit stores the temperature of the heating element measured with the temperature sensor at a predetermined timing from the ascent or descent start to the ascent or descent stop of the cage when components constituting the water-cooled cooling system are normal as a reference value under normal conditions. The abnormality detecting unit compares the reference value with the temperature of the heating element measured each time the cage ascends or descends and detects the abnormality in the water-cooled cooling system when a difference between the two temperatures exceeds a predetermined value.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

Fig. 1 is a perspective view of an elevator device according to the present embodiment;

Fig. 2 is a block diagram illustrating a control system of the elevator device according to the present embodiment;

Fig. 3 is a block diagram of a drive unit according to the present embodiment;

Fig. 4 is a conceptual drawing of a heat sink used in an inverter according to the present embodiment;

Fig. 5 is a block diagram of a water-cooled cooling system according to the

present embodiment;

Fig. 6 is a block diagram of a control unit according to the present embodiment;

Fig. 7A to Fig. 7C are diagrams for describing a temperature change of a heating element of the inverter according to the present embodiment;

Fig. 8 is a diagram for describing the temperature change of the heating element of the inverter according to the present embodiment;

Fig. 9 is a diagram for describing an identification of a cause of damage by an abnormality detecting unit according to the present embodiment; and

Fig. 10 is a flowchart for describing an abnormality detection process by an elevator abnormality detection device according to the present embodiment.

DETAILED DESCRIPTION

[0011]

The following describes the present embodiments using the drawings. An XYZ coordinate system constituted of an X-axis, a Y-axis, and a Z-axis, which are orthogonal to one another, is used for description as appropriate. The diagrams and flowchart used to describe the present embodiments are illustrated as examples.

[0012]

(Embodiment 1)

Fig. 1 is a perspective view of an elevator device 10 according to the present embodiment. The elevator device 10 is arranged inside an elevator shaft 11 disposed in a building, such as a commercial facility or residential facility. As illustrated in Fig. 1, the elevator device 10 has a cage 31, a counterweight 35, an hoist motor 40, a control panel 70 (elevator control device), and the like.

[0013]

The cage 31 is a unit that accommodates a user and ascends and descends through the elevator shaft 11. The cage 31 is arranged between guide rails and is movably attached with respect to guide rails 21 to 24 in a vertical direction.

[0014]

An opening 31a is formed on a side surface on the +X-side of the cage 31 to allow entry to and exit from the inside. The opening 31a is blocked or opened by a pair of doors 32 that move along the side surface of the cage 31. The doors 32 are opened and closed by an opening/closing motor (not illustrated in Fig. 1).

[0015]

The counterweight 35 is movably attached with respect to the guide rails 21 to 24 in the vertical direction. The weight of the counterweight 35 is adjusted to be a predetermined proportion of the weight of the cage 31.

[0016]

The hoist motor 40 is a motor for raising and lowering the cage 31. The hoist motor 40 is arranged at an upper portion of the elevator shaft 11 so as to have a rotation shaft parallel to the Y-axis. A pulley 42 is secured to the rotation shaft of the hoist motor 40. A wire 43 is wound around the pulley 42 of the hoist motor 40. The wire 43 has one end secured to the cage 31 and the other end secured to the counterweight 35.

[0017]

The control panel 70 is arranged in the elevator shaft 11. The control panel 70 houses a control device for controlling the hoist motor 40 and equipment and the like disposed in the cage 31. In the embodiment below, an elevator with no machine room in which the control panel 70 is arranged in the elevator shaft 11 is described as an example. However, the present embodiment can also be applied when there is a machine room.

[0018]

Although an illustration is omitted in Fig. 1, a second temperature sensor 38 that measures the temperature in the elevator shaft 11 is disposed near the control panel 70.

[0019]

Fig. 2 is a block diagram illustrating a control system of the elevator device 10. The control system is configured to include a control unit 80 and a drive unit 90 that are housed in the control panel 70, an operation panel 36 and a load sensor 37 that are disposed in the cage 31, and the second temperature sensor 38.

[0020]

The operation panel 36 is disposed on an inner wall surface of the cage 31. The operation panel 36 is an interface for receiving a destination floor or the like from the user of the cage 31. By operating the operation panel 36, the user can register the destination floor and the like of the cage 31 and open and close the doors 32.

[0021]

The load sensor 37 measures the load on the cage 31. The second temperature sensor 38 measures the temperature in the elevator shaft 11 (for example, near the control panel 70).

[0022]

The drive unit 90 illustrated in Fig. 2 drives the hoist motor 40 and an opening/closing motor 41 (not illustrated in Fig. 1) that drives the doors 32 of the cage 31, by supplying power to the hoist motor 40 and the opening/closing motor 41. The drive unit 90 drives the hoist motor 40 based on instructions from the control unit 80. In addition, the drive unit 90 drives the opening/closing motor 41 based on instructions from the control unit 80.

[0023]

Fig. 3 is a block diagram of the drive unit 90. The drive unit 90 has a converter 91 and an inverter 93. A smoothing capacitor 92 is disposed between the converter 91 and the inverter 93. The converter 91 converts the AC power of a commercial power supply 1 into power suitable for the inverter 93. The inverter 93 is a power supply device that supplies power to the hoist motor 40 and the opening/closing motor 41. In Fig. 3, the illustration of the opening/closing motor 41 is omitted. The inverter 93 is constituted of a switching regulator. When the hoist motor 40 and the opening/closing motor 41 are formed of three-phase AC motors, the inverter 93 outputs a three-phase AC voltage.

[0024]

For the output of the inverter 93, a power sensor 96 that measures the power supplied to the hoist motor 40 is disposed. In addition, a temperature sensor 97 that measures the temperature of a heating element is disposed near the heating element that constitutes the inverter 93 (for example, near a switching element and the like). The temperature sensor 97 measures the temperature of the heating element constituting the inverter 93 (power supply) when the cage 31 performs an ascent or descent operation.

[0025]

Referring again to Fig. 2, the control unit 80 is a computer that has a CPU, a main storage unit, an auxiliary storage unit, and an interface unit. The CPU executes a process described below in accordance with a program stored in the auxiliary storage unit. The main storage unit has RAM and the like. The main storage unit is used as a working area of the CPU. The auxiliary storage unit has non-volatile memory, such as ROM and semiconductor memory. The auxiliary storage unit stores the program executed by the CPU.

[0026]

The auxiliary storage unit stores various parameters, a graph indicating the temperature change of the heating element constituting the inverter 93 in accordance with the ascent and descent of the cage 31, and the like. In detail, the auxiliary storage unit stores the temperature of the heating element measured with the temperature sensor at a predetermined timing between the ascent or descent start and the ascent or descent stop of the cage 31 when the components constituting the water-cooled cooling system are normal as reference values under normal conditions. The auxiliary storage unit stores a graph indicating the temperature change from the ascent or descent start to the ascent or descent stop of the cage 31 under normal conditions as a graph of the reference values under normal conditions. The auxiliary storage unit stores the temperature of the heating element at the predetermined timing between the ascent or descent start and the ascent or descent stop of the cage 31 when the component constituting the water-cooled cooling system suffers damage as a reference value under damage conditions. The auxiliary storage unit stores a graph indicating the temperature change from the ascent or descent start to the ascent or descent stop of the cage 31 when the component constituting the water-cooled cooling system suffers damage as a graph of the reference value under damage conditions.

[0027]

The interface unit has a serial interface, a parallel interface, a wireless LAN interface, and the like. The operation panel 36 and the drive unit 90 are connected to the CPU via the interface unit. In addition, an input/output unit 100 constituted of a keyboard, a display, and the like is connected to the interface unit.

[0028]

Fig. 4 is a conceptual drawing of a heat sink 300 used in the inverter 93. Heating elements 921 are switching elements that constitute the inverter 93. Here, eight

heating elements 921 are arranged as illustrated in Fig. 4. The heat sink 300 is disposed to cool a plurality of heating elements 921. The heat sink 300 has a heat-receiving plate 310 arranged in contact with the plurality of heating elements 921 and a plurality of heat radiating fins 320 arranged on a surface ($-Z$ -side surface) opposite to a surface ($+Z$ -side surface) of the heat-receiving plate 310 in contact with the heating elements 921. A plurality of pipes 210 are disposed in the heat-receiving plate 310. The inverter 93 may have a plurality of boards as illustrated in Fig. 4. The temperature sensor 97 may be disposed for each board or may be disposed for each heating element 921.

[0029]

In Fig. 4, a plurality of fans 350 for forced air cooling are disposed on the $+Y$ -side of the heat sink 300. For example, forced air cooling allows cold air to be blown in the Y -axis direction. In the example illustrated in Fig. 4, two cooling systems are used. One is an air-cooled cooling system with the fans 350, and the other is a water-cooled cooling system with the pipes 210.

[0030]

Fig. 5 is a block diagram of a water-cooled cooling system 200. The water-cooled cooling system 200 has the pipes 210, a pump 220, a radiator 230, and a tank 240. The pipes 210 internally contain water as a refrigerant and cool the heat sink 300 of the inverter 93. For example, as illustrated in Fig. 4, the pipes 210 are arranged to pass through the heat-receiving plate 310 of the heat sink 300. The pump 220 causes water flowing through the pipes 210 to flow. The radiator 230 cools the water flowing through the pipes 210. The radiator 230 has one or a plurality of cooling fans. The tank 240 is a container that stores water. Having the tank 240 that stores water can suppress the rise in temperature of the water in the pipes 210. The tank 240 is arranged, for example, between the radiator 230 and the pump 220.

[0031]

Fig. 6 is a functional block diagram of the control unit 80. The CPU of the control unit 80 realizes a drive unit control unit 71 and an abnormality detection device 72 by executing the program stored in the auxiliary storage unit.

[0032]

The drive unit control unit 71 controls the drive unit 90 based on input from the operation panel 36 or a calling panel on each floor. For example, when the drive unit control unit 71 normally rotates the hoist motor 40 through the drive unit 90, the cage 31 ascends, and the counterweight 35 descends. When the drive unit control unit 71 reversely rotates the hoist motor 40 through the drive unit 90, the cage 31 descends, and the counterweight 35 ascends. In addition, when the drive unit control unit 71 normally rotates the opening/closing motor 41 through the drive unit 90, the doors 32 of the cage 31 and doors disposed in a riding area on each floor are controlled to open. When the drive unit control unit 71 reversely rotates the opening/closing motor 41 through the drive unit 90, the doors 32 of the cage 31 and the doors disposed in the riding area on each floor are controlled to close.

[0033]

The abnormality detection device 72 is a device that detects an abnormality in the water-cooled cooling system 200. The abnormality detection device 72 has an operation status monitoring unit 721, a graph generation unit 722, an abnormality detecting unit 723, and a storage unit 724.

[0034]

The operation status monitoring unit 721 monitors the operation status, such as a load weight, a travel distance, and a frequency of operation of the cage 31. The heavier the load weight and the longer the travel distance, the greater the output power of the

inverter 93. In addition, the higher the frequency of cage operation, the higher the temperature of the switching elements because the inverter 93 runs before the temperature of the switching elements that constitute the inverter 93 decreases. The operation status monitoring unit 721 can acquire information on the load weight from the load sensor 37 and information on the travel distance and the frequency of cage operation from the drive unit control unit 71. Here, a case in which power per unit time supplied by the inverter 93 to the hoist motor 40 that drives the ascent and descent of the cage 31 is used as an indicator that indicates the operating state of the cage 31 is described. Since the power measured with the power sensor 96 included in the drive unit 90 varies according to the operation status, such as the load weight on the cage 31, the travel distance of the cage 31, and the frequency of cage operation, it can be used as an indicator that indicates the operation status. For example, the operation status monitoring unit 721 monitors the power per hour measured with the power sensor 96.

[0035]

The graph generation unit 722 generates a graph indicating the temperature change from the ascent or descent start to the ascent or descent stop of the cage 31 based on temperature data measured with the temperature sensor 97 included in the inverter 93. The graph generation unit 722 associates the amount of power that is measured with the operation status monitoring unit 721 and indicates the operation status with the information of the generated graph.

[0036]

The storage unit 724 stores the graph generated by the graph generation unit 722 when the water-cooled cooling system 200 is normal as the graph of the reference values under normal conditions. The temperature of the heating element of the inverter 93 differs depending on the operation status, such as a load weight, a travel distance, and a

frequency of operation of the cage 31. For the temperature of the heating element of the inverter 93, the environmental temperature at which the inverter 93 is provided changes depending on the season. For example, even in the same operation status, the temperature of the heating element of the inverter 93 differs between summer and winter, or daytime and nighttime. The storage unit 724 uses the amount of power per hour measured with the power sensor 96 and the environmental temperature measured with the second temperature sensor 38 as parameters and stores the graph of the reference values under normal conditions for each combination of the parameters. The graphs of the reference values under normal conditions are generated for each travel distance of the cage 31.

[0037]

The graphs of the reference values stored in the storage unit 724 include graphs indicating the temperature change when the components (pipes 210, pump 220, radiator 230, and the like) constituting the water-cooled cooling system 200 each suffer damage and a graph of a threshold for determining whether the state is normal or abnormal.

[0038]

Fig. 7A to Fig. 7C are conceptual drawings of the temperature change of the heating element 921 of the inverter 93 in accordance with the ascent and descent of the cage 31. Fig. 7A to Fig. 7C illustrate an example of the case where the cage 31 moves from the first floor to the tenth floor. Fig. 7A illustrates the speed change of the cage 31. The cage 31 accelerates up to a predetermined speed in the period from t_0 to t_1 and ascends at the predetermined speed in the period from t_1 to t_4 . Then, the cage 31 decelerates before the tenth floor as the destination floor (t_4) and stops at the tenth floor as the destination floor (t_5).

[0039]

Fig. 7B is a conceptual drawing of a change of current supplied from the inverter 93 to the hoist motor 40. To accelerate the cage 31, the current greater than that during the ascent at the constant speed is required. Therefore, the current increases in the period from t_0 to t_1 and slightly decreases in the period from t_1 to t_2 . In the period from t_2 to t_3 , the current corresponding to the ascent/descent speed of the cage 31 is supplied from the inverter 93 to the hoist motor 40. In the period from t_3 to t_4 , the current slightly increases to brake the cage 31 ascending or descending. In the period from t_4 to t_5 , the current supplied from the inverter 93 to the hoist motor 40 decreases in accordance with the deceleration of the ascent/descent speed of the cage 31.

[0040]

Fig. 7C is a conceptual drawing of the temperature change of the heating element 921 of the inverter 93 measured with the temperature sensor 97. The temperature of the heating element 921 changes in proportion to the value of the current illustrated in Fig. 7B.

[0041]

Fig. 8 is a diagram illustrating different patterns of the temperature change corresponding to the causes of damage of the water-cooled cooling system 200. The bottom solid line in Fig. 8 is the graph of the reference values under normal conditions of the water-cooled cooling system 200. When the water-cooled cooling system 200 suffers damage, the cooling effect reduces. The degree of reduction of the cooling effect differs depending on the cause of damage. Here, three causes of damage are described as examples. Fig. 9 is a table indicating the relation between the temperature change pattern and the cause of damage. The graphs indicating the temperature change of patterns 1 to 3 illustrated in Fig. 8 correspond to the respective causes of damage.

[0042]

In the graph of the pattern 3 illustrated in Fig. 8, the temperature rise is slightly greater than that in the graph of the reference values under normal conditions (the reference values under normal conditions). The graph of the pattern 3 is a graph indicating the temperature change when, for example, a partial stoppage of the radiator 230 or clogging of the radiator 230 is the cause of damage. The partial stoppage of the radiator 230 means that a fan included in the radiator 230 stops while the radiator 230 is operating. When the radiator 230 includes a plurality of fans, a case where any of the fans stops is included. The graph of the pattern 2 illustrated in Fig. 8 indicates the temperature rise greater than that of the pattern 3. The graph of the pattern 2 is a graph indicating the temperature change when, for example, a complete stoppage of the radiator 230 or a small amount of water leakage due to a crack in the pipe 210 or the tank 240 is the cause of damage. The graph of the pattern 1 illustrated in Fig. 8 indicates the temperature rise greater than that of the pattern 2. The graph of the pattern 1 is a graph indicating the temperature change when, for example, a damage of the pump or a large amount of water leakage due to a crack in the pipe 210 or the tank 240 is the cause of damage. A case where the joint between the pipes 210 suffers damage and the cold water is not supplied to the pipes 210 provided inside the heat sink 300 is also included.

[0043]

The cage 31 is caused to ascend and descend in the state where the assumed causes of damage are purposely created, and the graphs are generated with the graph generation unit 722 and stored in the storage unit 724 as the graphs (the graphs of pattern 1, pattern 2, and pattern 3) of the reference value in the case having the cause of damage. The graph illustrated by a dashed line in Fig. 8 is a graph of the threshold to determine whether the state is normal or abnormal. The graph of the threshold is set to be positioned between the graph of the reference values under normal conditions illustrated

by the solid line at the bottom of Fig. 8 and the graph of the pattern 3 indicating the smallest deterioration of the cooling effect.

[0044]

The graphs of the reference values under damage conditions of the patterns 1 to 3 (the reference values under damage conditions) and the graph of the reference values under normal conditions (the reference values under normal conditions) illustrated in Fig. 8 are generated by using the load weight, the travel distance, and the frequency of operation (summed value of the output current per hour of the inverter 93) of the cage 31 and the environmental temperature measured with the second temperature sensor 38 as the parameters and changing the combination of the parameters. The graphs of the reference values illustrated in Fig. 8 are generated for each combination of the parameters and stored in the storage unit 724.

[0045]

By referring again to Fig. 6, the abnormality detecting unit 723 detects the abnormality by comparing the graph of the reference value with the graphs generated each time the cage 31 ascends or descends by the graph generation unit 722. Specifically, the abnormality detecting unit 723 uses the amount of power per hour measured with the power sensor 96, the environmental temperature measured with the second temperature sensor 38, and the travel distance, which are measured at the ascent or descent operation of the cage 31, as the parameters and extracts the graph of the reference value corresponding to the parameters from the storage unit 724. Then, the abnormality detecting unit 723 compares the graph generated corresponding to the ascent or descent of the cage 31 by the graph generation unit 722 with the reference value (graph of the reference value) extracted from the storage unit 724. Then, when a temperature difference between the two sides (temperature difference in the period from t_2 to t_3 in

Fig. 7A to Fig. 7C) exceeds a predetermined value, the abnormality detecting unit 723 detects the occurrence of abnormality in the water-cooled cooling system 200. Specifically, when the graph generated corresponding to the ascent or descent of the cage 31 by the graph generation unit 722 exceeds the threshold indicated by the dashed line in Fig. 8, the occurrence of abnormality is detected.

[0046]

When the abnormality detecting unit 723 detects an abnormality, it outputs to the input/output unit 100 that an abnormality has occurred. In addition, the abnormality detecting unit 723 notifies the drive unit control unit 71 that an abnormality has occurred. When the drive unit control unit 71 receives the notification that an abnormality has occurred, it controls the drive unit 90 to operate the cage in safety mode. The safety mode is the operation in which the ascent/descent acceleration and ascent/descent speed of the cage 31 are reduced compared to normal operation.

[0047]

Next, an elevator abnormality detection method is described with reference to a flowchart illustrated in Fig. 10. The following control is performed based on the program stored in the auxiliary storage unit, and the control is performed by the control unit 80 (CPU).

[0048]

The reference values are acquired before operating the elevator device 10 (Step S11). In detail, the graph illustrating the temperature change of the heating elements 921 when the components constituting the water-cooled cooling system 200 are normal is stored as the graph as the reference under normal conditions (the graph of the solid line at the bottom of Fig. 8) in the storage unit 724. The temperature of the heating element 921 at the predetermined timing between the ascent or descent start and the ascent or

descent stop of the cage 31 when the components constituting the water-cooled cooling system 200 are normal is the temperature as the reference under normal conditions. The graph illustrating the temperature change of the heating element 921 when the component constituting the water-cooled cooling system 200 suffers damage is stored as the graph as the reference under damage conditions (the graphs of the patterns 1 to 3 of Fig. 8) in the storage unit 724. The temperature of the heating element 921 at the predetermined timing between the ascent or descent start and the ascent or descent stop of the cage 31 when the component constituting the water-cooled cooling system 200 suffers damage is the temperature as the reference under damage conditions. Step S11 is a storing step.

[0049]

The graph as the reference under normal conditions and the graph as the reference under damage conditions are acquired under conditions in which the combination of parameters of the load weight, the travel distance, and the frequency of operation of the cage 31 and the environmental temperature measured with the second temperature sensor 38 is changed. Here, power per unit time supplied by the inverter 93 to the hoist motor 40 that drives the ascent and descent of the cage 31 is used as an indicator that indicates the operating state of the cage 31, including the load weight, the travel distance, and the frequency of operation of the cage 31. By using the power per unit time supplied by the inverter 93 to the hoist motor 40 that drives the ascent and descent of the cage 31 as an indicator that indicates the operating state of the cage 31, including the load weight, the travel distance, and the frequency of operation of the cage 31, the number of pieces of data acquired as parameters can be reduced. In addition, the combinations of parameters can be reduced, thereby reducing the process of the CPU.

[0050]

Once the elevator device 10 is in operation, the operation status monitoring unit

721 monitors the operation status by monitoring the output power of the inverter 93 (for example, output power per hour) (Step S12).

[0051]

The abnormality detection device 72 monitors whether or not an ascent or descent operation of the cage 31 has been performed (Step S13). The abnormality detection device 72 monitors this by acquiring the information indicating whether or not the ascent or descent operation of the cage 31 has been performed from the drive unit control unit 71.

[0052]

When the ascent or descent operation of the cage 31 has been performed (Step S13: Yes), the operation status monitoring unit 721 acquires the information on the load weight of the cage 31 from the load sensor 37, the information on the travel distance of the cage 31 from the drive unit control unit 71, and the information on the environmental temperature from the second temperature sensor 38 (Step S14). The power per unit time (for example, per hour) supplied by the inverter 93 to the hoist motor 40 that drives the ascent and descent of the cage 31 is used as an indicator that indicates the operating state.

[0053]

Next, the graph generation unit 722 acquires the temperature of the heating element 921 during the ascent or descent operation of the cage 31 from the temperature sensor 97. The step of acquiring the temperature of the heating elements 921 during the ascent or descent operation of the cage 31 from the temperature sensor 97 is a temperature measuring step. Then, the graph generation unit 722 generates the graph (graph of Fig. 7C) illustrating the change in the heating element 921 of the inverter 93 in accordance with the ascent and descent of the cage 31 (Step S15).

[0054]

Next, the abnormality detecting unit 723 extracts the graph of the reference value illustrated in Fig. 8 corresponding to the parameters of the load weight of the cage 31, the travel distance of the cage 31, the operating state, and the environmental temperature, which have been acquired by the operation status monitoring unit 721, from the storage unit 724. Then, by comparing the graph illustrating the temperature change generated in Step S15 with the graph of the threshold (graph indicated by the dashed line in Fig. 8) in the graphs of the reference values, whether or not there is an abnormality in the water-cooled cooling system 200 is determined (Step S16). Step S16 is an abnormality detecting step.

[0055]

When the graph illustrating the temperature change generated by the graph generation unit 722 exceeds the threshold of the graph as the reference (Step S16: Yes), the abnormality detecting unit 723 determines that a damage has occurred in the water-cooled cooling system 200. Additionally, the abnormality detecting unit 723 determines which of the graphs of the patterns 1 to 3 the graph illustrating the temperature change generated by the graph generation unit 722 in Step S14 is close to, and estimates the cause of damage of the water-cooled cooling system 200 based on the correspondence table illustrated in Fig. 9 (Step S17).

[0056]

The abnormality detecting unit 723 outputs the occurrence of damage and the estimated cause of damage to the drive unit control unit 71 and the input/output unit 100 (Step S18). The drive unit control unit 71 drives the cage 31 in the safety mode according to the cause of damage (Step S19). The safety mode is the operation in which the ascent/descent acceleration and ascent/descent speed of the cage 31 are reduced compared to normal operation. By operating in the safety mode, the amount of heat

generated by the inverter 93 can be suppressed, and damage of the inverter 93 can be suppressed.

[0057]

As described above, the elevator abnormality detection device 72 according to the embodiment detects the abnormality in the water-cooled cooling system 200 based on the degree of divergence between the temperature measured each time the cage 31 ascends or descends and the reference value. Specifically, the elevator abnormality detection device 72 according to the embodiment has the temperature under normal conditions of the water-cooled cooling system 200 measured with the temperature sensor 97 at the predetermined timing between the ascent or descent start and the ascent or descent stop of the cage 31 as the reference value, and detects the abnormality by comparing the reference value with the temperature measured each time the cage 31 ascends or descends. By the abnormality determination as described above, the elevator abnormality detection device 72 according to the embodiment can accurately detect the abnormality in the water-cooled cooling system 200.

[0058]

The elevator abnormality detection device 72 according to the embodiment has the temperature at the predetermined timing between the ascent or descent start and the ascent or descent stop of the cage 31 when the component constituting the water-cooled cooling system 200 suffers damage as the reference value under damage conditions, and estimates the cause of damage of the water-cooled cooling system 200 by comparing the reference value under damage conditions with the temperature measured each time the cage 31 ascends or descends. This allows the elevator abnormality detection device 72 according to the embodiment to identify the cause of damage of the water-cooled cooling system 200 used in the elevator device.

[0059]

The elevator abnormality detection device 72 according to the embodiment has the reference values corresponding to the combinations of the parameters of the load weight, the travel distance, and the frequency of operation of the cage 31 and the environmental temperature, and detects the occurrence of abnormality in the water-cooled cooling system 200 by the comparison with the reference values corresponding to the combinations of the parameters of the load weight, the travel distance, and the frequency of operation of the cage 31 and the environmental temperature, thereby estimating the cause of damage of the water-cooled cooling system 200. Since the elevator abnormality detection device 72 according to the embodiment compares the reference values under normal conditions corresponding to parameter conditions (combinations of the parameters) classified in detail with the values measured each time the cage 31 ascends or descends, the accuracy of detecting the damage of the water-cooled cooling system 200 used in the elevator device can be enhanced. Since the elevator abnormality detection device 72 according to the embodiment compares the reference values under damage conditions corresponding to parameter conditions classified in detail with the values measured each time the cage 31 ascends or descends, the accuracy of estimating the cause of damage of the water-cooled cooling system 200 can be improved.

[0060]

While the embodiment of the present invention has been described above, the present invention is not limited to the above-described embodiment. For example, in the above description, for ease of understanding, the graph generation unit 722 generates the graph as illustrated in Fig. 8. However, the graph generation unit 722 does not need to generate the graph as illustrated in Fig. 8, and it is sufficient to record time-series data in a set of (time, temperature). It is sufficient that the abnormality detecting unit 723

determines whether or not there is an abnormality based on the time-series data and estimates the cause of damage.

[0061]

The time it takes for the cage 31 to reach the constant speed after the ascent or descent start is determined based on the ascent or descent distance of the cage 31. Therefore, the time up to approximate the middle between t_2 and t_3 of Fig. 8 is determined depending on the ascent or descent distance of the cage 31. The abnormality detecting unit 723 may acquire temperature information from the temperature sensor 97 at this timing to determine whether or not there is an abnormality. In this case, the graph generation unit 722 can be omitted.

[0062]

While the description is omitted above, the graphs of the reference values under normal conditions and under damage conditions with the changed combinations of the parameters of the load weight, the travel distance, and the frequency of operation (summed value of the output current per hour of the inverter 93) of the cage 31 and the environmental temperature measured with the second temperature sensor 38 can be generated by moving up or down the cage 31 in the state where the causes of damage illustrated in Fig. 9 are purposely created and actually measuring the temperature change. Also, the graphs of the reference values under normal conditions and under damage conditions can be generated by simulations with the changed cause of damage and parameter.

[0063]

Regular periodic inspections of elevator devices are carried out every few months. For example, if cracks occur in the pipes 210 of the water-cooled cooling system 200, the water in the pipes 210 and the tank 240 will be depleted before the next

periodic inspection, reducing the cooling effect. In this case, the inverter 93 is more likely to suffer damage because the semiconductors that constitute the inverter 93 cannot be cooled. Therefore, it is preferable that the inspection by the elevator abnormality detection device 72 be performed, for example, upon each ascent or descent operation of the cage 31, or on a daily basis, such as at night.

[0064]

(Modification 1)

In the above description, the abnormality in the water-cooled cooling system 200 is detected by comparing the temperatures of the period between t_2 and t_3 of Fig. 8. In another embodiment, the graphs of the reference values under normal conditions and under damage conditions illustrated in Fig. 8 may be compared with the graphs generated each time the cage 31 ascends or descends. While the process amount increases compared with the process of comparing the temperatures at the predetermined timing (1 point) between the ascent or descent start and the ascent or descent stop of the cage 31, there is a possibility that the temperature graph has a waveform different from that in normal operation due to a damage, and the comparison of the graphs may detect the abnormality. Peak values of the temperatures (temperatures at the time t_1 of Fig. 8) may be compared.

[0065]

(Modification 2)

In the above description, a case of passing water through the pipes 210 is described. However, the medium that cools the heat sink 300 is not necessarily limited to water. For example, various kinds of gases called chlorofluorocarbons used in air conditioners may be acceptable. In this case, the water-cooled cooling system 200 illustrated in Fig. 5 is configured to include an expansion valve instead of the pump 220

and have a compressor between the heat sink 300 and the radiator 230.

[0066]

(Embodiment 2)

In Embodiment 2, a case where Artificial Intelligence (AI) is used for the abnormality detecting unit 723 is described. When the AI is used for the abnormality detecting unit 723, the reference values (graphs as the reference) under normal conditions and under damage conditions of the water-cooled cooling system 200 described in Step S11 of Embodiment 1 are stored as labeled training data in the storage unit 724. Specifically, the graph illustrated in Fig. 8 can be used as the labeled learning data. The labeled training data under damage conditions is data associated with the causes of damage illustrated in Fig. 9. The labeled training data under normal conditions is associated with information such as "no damage." The labeled training data is generated with data in which combinations of the parameters of the load weight, the travel distance, and the frequency of operation of the cage 31 and the environmental temperature measured with the second temperature sensor 38 are changed. The labeled training data preferably includes multiple graphs measured under the same conditions. The labeled training data may be generated by simulations.

[0067]

In Step S15, the information on the load weight of the cage 31, the information on the travel distance of the cage 31, and the information on the environmental temperature from the second temperature sensor 38 acquired in Step S14 are associated with the graphs illustrating the change in the heating element 921 of the inverter 93 in accordance with the ascent or descent of the cage 31 generated in Step S15. Then, in Step S16, the AI compares the labeled training data stored in the storage unit 724 with the graph generated each time the cage 31 ascends or descends in Step S15, thereby

determining whether or not there is an abnormality in the water-cooled cooling system 200.

[0068]

When it is determined that the graph generated each time the cage 31 ascends or descends has the highest correlation with the labeled training data of "no damage," the AI determines that there is no abnormality in the water-cooled cooling system 200 (Step S16: No).

[0069]

On the other hand, when it is determined that the graph generated each time the cage 31 ascends or descends has the highest correlation with any of the graphs of the patterns 1 to 3 of Fig. 8, the AI estimates the cause of damage indicated by the labeled training data under damage conditions having the highest correlation as the cause of damage (Step S17).

[0070]

The labeled training data may be the peak temperature at t1 of Fig. 8 or the temperature between t2 and t3 of Fig. 8 instead of the graph illustrated in Fig. 8.

[0071]

While some embodiments of the present invention have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. The novel embodiments described herein can be embodied in a variety of other configurations, and various omissions, substitutions, and changes can be made without departing from the gist of the invention. These embodiments and their modifications are included in the scope of the invention described in the claims and their equivalents as well as included in the scope and the gist of the invention.

REFERENCE SIGNS LIST

[0072]

10	elevator device
11	elevator shaft
21 to 24	guide rail
31	cage
31a	opening
32	door
35	counterweight
36	operation panel
37	load sensor
38	second temperature sensor
40	hoist motor
41	opening/closing motor
42	pulley
43	wire
70	control panel
71	drive unit control unit
72	abnormality detection device
721	operation status monitoring unit
722	graph generation unit
723	abnormality detecting unit
80	control unit
90	drive unit
91	converter

93	inverter
96	power sensor
97	temperature sensor
100	input/output unit
200	water-cooled cooling system
210	pipe
220	pump
230	radiator
300	heat sink
310	heat-receiving plate
320	heat radiating fin
350	fan
921	heating element

What is claimed is:

1. An elevator abnormality detection device that detects an abnormality in a water-cooled cooling system that cools a power supply that supplies power to a motor that drives ascent and descent of a cage, the elevator abnormality detection device comprising:

a temperature sensor that measures a temperature of a heating element constituting the power supply when the cage performs an ascent or descent operation;

a storage unit that stores the temperature of the heating element measured with the temperature sensor at a predetermined timing between the ascent or descent start and the ascent or descent stop of the cage when components constituting the water-cooled cooling system are normal as a reference value under normal conditions; and

an abnormality detecting unit that compares the reference value with the temperature of the heating element measured each time the cage ascends or descends and detects the abnormality in the water-cooled cooling system when a difference between the two temperatures exceeds a predetermined value.

2. The elevator abnormality detection device according to claim 1, wherein

the storage unit stores the temperature of the heating element at the predetermined timing between the ascent or descent start and the ascent or descent stop of the cage when a component constituting the water-cooled cooling system suffers damage as a reference value under damage conditions, and

the abnormality detecting unit compares the reference value under damage conditions with the temperature of the heating element measured each time the cage ascends or descends to estimate a cause of damage of the water-cooled cooling system.

3. The elevator abnormality detection device according to claim 1 or 2, wherein

the reference value under normal conditions and the reference value under damage conditions are set corresponding to combinations of a load weight, a travel distance, and a frequency of operation of the cage and an environmental temperature.

4. The elevator abnormality detection device according to claim 3, wherein
as an indicator indicating an operating state of the cage including the load weight, the travel distance, and the frequency of operation of the cage, the power per unit time supplied by the power supply to the motor that drives the ascent and descent of the cage is used.

5. The elevator abnormality detection device according to claim 1, comprising
a graph generation unit that generates a graph indicating a temperature change from the ascent or descent start to the ascent or descent stop of the cage based on temperature data measured with the temperature sensor, wherein

the storage unit stores a graph generated by the graph generation unit when the water-cooled cooling system is normal as a graph of the reference value under normal conditions, and

the abnormality detecting unit detects the abnormality by comparing the graph of the reference value under normal conditions with a graph generated by the graph generation unit each time the cage ascends or descends.

6. The elevator abnormality detection device according to claim 5, wherein
the storage unit stores a graph generated by the graph generation unit when a component constituting the water-cooled cooling system suffers damage as a graph of the reference value under damage conditions, and

the abnormality detecting unit estimates a cause of damage of the water-cooled cooling system based on the graph as a reference under damage conditions and the graph generated by the graph generation unit each time the cage ascends or descends.

7. An elevator abnormality detection method for detecting an abnormality in a water-cooled cooling system that cools a power supply that supplies power to a motor that drives ascent and descent of a cage, the elevator abnormality detection method comprising:

a storing step of measuring a temperature of a heating element constituting the power supply with a temperature sensor at a predetermined timing between the ascent or descent start and the ascent or descent stop of the cage and storing a temperature under normal conditions of the water-cooled cooling system as a reference value under normal conditions;

a temperature measuring step of measuring the temperature of the heating element constituting the power supply each time the cage ascends or descends; and

an abnormality detecting step of detecting the abnormality in the water-cooled cooling system by comparing the reference value under normal conditions with the temperature measured each time the cage ascends or descends.

8. The elevator abnormality detection method according to claim 7, wherein

in the storing step, the temperature at the predetermined timing between the ascent or descent start and the ascent or descent stop of the cage when a component constituting the water-cooled cooling system suffers damage is stored as a reference value under damage conditions, and

in the abnormality detecting step, the reference value under damage conditions

is compared with the temperature measured each time the cage ascends or descends to estimate a cause of damage of the water-cooled cooling system.