

ELEVATOR ABNORMALITY DETECTION DEVICE

BACKGROUND

1. Technical Field

[0001]

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

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, semiconductors 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. When 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 the 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 determine whether or not the cooling system has suffered damage.

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 plurality of pipes, a tank, a pump, and a radiator. The causes of damage to the water-cooled cooling system are complex and include, for example, cracks in the pipes, stops of a 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 determine whether or not it has suffered damage.

[0008]

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

SUMMARY

[0009]

An 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 storage unit that stores at least one of a value of drive current of a pump under normal conditions, a water pressure value in a pipe under normal conditions, a value of flow rate of water flowing through the pipe under normal conditions, a value of vibration produced by the water-cooled cooling system under normal conditions, and a value of sound produced by the water-cooled cooling system under normal conditions as a reference value, and an abnormality detecting unit that compares at least one of a measured value of drive current, a measured water pressure value in the pipe, a measured value of flow rate of water flowing through the pipe, a measured value of vibration produced by the water-cooled cooling system, and a measured value of sound produced by the water-cooled cooling system, with the reference value, and detects that an abnormality has occurred in the water-cooled cooling system when a difference between the measured value and the reference value exceeds a predetermined value. The measured value is measured each time the cage ascends or descends.

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. 7 is a flowchart for describing an abnormality detection process by an elevator abnormality detection device according to the present embodiment; and

Fig. 8 is a drawing for describing the estimation of the causes of damage by an abnormality detecting unit 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 that are orthogonal to one another is used for description as appropriate. The diagrams and flowchart used to describe the present embodiments illustrate 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 a residential facility. As illustrated in Fig. 1, the elevator device 10 has a cage 31, a counterweight 35, a 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 among guide rails and is movably attached to guide rails 21 to 24 in the 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 to the guide rails 21 to 24 in the vertical direction. The weight of the counterweight 35 is adjusted to be a predetermined proportion to 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 will be 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 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 disposed in the cage 31, a load sensor 37, and the 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 is a sensor that measures the load weight of the cage 31. The temperature sensor 38 is a sensor that measures the temperature (environmental 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 that drives the ascent and descent of the cage 31 and an opening/closing motor 41 (not illustrated in Fig. 1) that drives opening and closing of 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 current 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 near a heat sink).

[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. In addition, the auxiliary storage unit stores data indicating the state of a water-cooled cooling system under normal conditions (a value of drive current of a pump, a water pressure value in a pipe, a value of flow rate of water flowing through the pipe, a value of vibration, and a value of sound) as reference values.

[0026]

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.

[0027]

Fig. 4 is a conceptual drawing of a heat sink 300 used in the inverter 93. Heating elements 921 are switching elements and the like 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 substrates, such as the substrate illustrated in Fig. 4. In this case, the heat sink 300 may be disposed for each substrate. In addition, a plurality of heat sinks 300 may be disposed in one substrate. The temperature sensor 97 may be disposed for each heating element 921, may be disposed for each heat sink 300, or may be disposed for each substrate.

[0028]

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.

[0029]

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 disposed in 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 the temperature of the water in the pipes 210. The tank 240 is arranged, for example, between the radiator 230 and the pump 220.

[0030]

The pump 220 regulates the flow rate of the water flowing through the pipes 210 based on the control of a pump motor control unit 222. The pump motor control unit 222 is controlled from a drive unit control unit 71 described later. The drive unit control unit 71 controls the inverter 93 to output the power required to drive the cage 31 based on the load or the travel distance of the cage 31. The amount of heat generated by the heating elements 921 of the inverter 93 correlates with the output power of the inverter 93. By controlling the pump motor control unit 222 based on control information that controls the inverter 93, the drive unit control unit 71 controls the flow rate of water caused to flow by the pump 220 so that the temperature of the heating elements 921 of the inverter 93 is equal to or lower than a predetermined temperature. That is, the flow rate of the water in the pipes 210 caused to flow by the pump 220 varies in response to the amount of heat generated by the inverter 93.

[0031]

The pump 220 includes a current sensor 250 that measures the current that drives

the pump 220 (the current supplied to the pump 220). The flow rate of water caused to flow by the pump 220 correlates with the current that drives the pump 220.

[0032]

In addition, a vibration sensor 251 and a sound sensor 252 are disposed near the pump 220. The vibration sensor 251 measures vibration produced by the pump 220. The sound sensor 252 measures sound produced by the pump 220.

[0033]

Further, in the pipes 210, a water pressure sensor 253 that measures the water pressure in the pipes 210 and a water flow sensor 254 that measures the flow rate of the water flowing through the pipes 210 are disposed. The water pressure sensor 253 and the water flow sensor 254 are arranged at any positions. While Fig. 5 illustrates a case in which the water pressure sensor 253 and the water flow sensor 254 are disposed between the heat sink 300 and the radiator 230, they may be, for example, disposed between the pump 220 and the heat sink 300.

[0034]

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

[0035]

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 provided at 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 provided at the riding area on each floor are controlled to close.

[0036]

Moreover, by controlling the pump motor control unit 222, the drive unit control unit 71 controls the flow rate of water caused to flow by the pump 220 so that the temperature of the heating elements 921 of the inverter 93 is equal to or lower than a predetermined temperature.

[0037]

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 storage unit 722, and an abnormality detecting unit 723.

[0038]

The operation status monitoring unit 721 monitors the operation status, such as the load weight, the travel distance, and the frequency of cage operation. 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 varies according to the operation status, such as the load weight of 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.

[0039]

The storage unit 722 stores the value of the drive current of the pump 220 under normal conditions as a reference value. The storage unit 722 also stores the water pressure value in the pipes 210 under normal conditions as a reference value. The storage unit 722 also stores the flow rate of water flowing through the pipes 210 under normal conditions as a reference value. The storage unit 722 also stores the value of vibration produced by the pump 220 under normal conditions as a reference value. The storage unit 722 also stores the value of sound produced by the pump 220 under normal conditions as a reference value. The values of vibration and sound include information on the magnitude and frequency components.

[0040]

The temperature of the heating elements 921 of the inverter 93 also varies with the temperature of an environment in which the inverter 93 is arranged. For example, the temperature of the heating elements 921 of the inverter 93 is different in summer and winter and in the daytime and the nighttime even under the same operation status. Using the power per hour measured with the power sensor 96 and the environmental temperature measured with the temperature sensor 38 as parameters, for each combination of these parameters, the storage unit 722 stores the value of the drive current of the pump 220

under normal conditions, the water pressure value, the value of the flow rate of water, the value of vibration, and the value of sound as reference values. The reference values are created for each travel distance of the cage 31 (for example, from the first floor to the fifth floor, from the fifth floor to the seventh floor, and the like).

[0041]

The abnormality detecting unit 723 compares a measured value of the drive current of the pump 220 measured with the current sensor 250 each time the cage 31 ascends or descends with the reference value stored in the storage unit 722, and detects that an abnormality has occurred in the water-cooled cooling system 200 when a difference between the measured value and the reference value exceeds a predetermined value. The abnormality detecting unit 723 also compares a measured value of the water pressure measured with the water pressure sensor 253 each time the cage 31 ascends or descends with the reference value stored in the storage unit 722, and detects that an abnormality has occurred in the water-cooled cooling system 200 when the difference between the measured value and the reference value exceeds a predetermined value. The abnormality detecting unit 723 also compares a measured value of the flow rate of water measured with the water flow sensor 254 each time the cage 31 ascends or descends with the reference value stored in the storage unit 722, and detects that an abnormality has occurred in the water-cooled cooling system 200 when the difference between the measured value and the reference value exceeds a predetermined value. The abnormality detecting unit 723 also compares a measured value of vibration measured with the vibration sensor 251 each time the cage 31 ascends or descends with the reference value stored in the storage unit 722, and detects that an abnormality has occurred in the water-cooled cooling system 200 when the difference between the measured value and the reference value exceeds a predetermined value. The abnormality detecting unit 723

also compares a measured value of sound measured with the sound sensor 252 each time the cage 31 ascends or descends with the reference value stored in the storage unit 722, and detects that an abnormality has occurred in the water-cooled cooling system 200 when the difference between the measured value and the reference value exceeds a predetermined value. The abnormality detecting unit 723 detects that an abnormality has occurred in the water-cooled cooling system 200 even when the frequency component of the vibration measured with the vibration sensor 251 contains a frequency component that is not detected under normal conditions. In addition, the abnormality detecting unit 723 detects that an abnormality has occurred in the water-cooled cooling system 200 even when the frequency component of the sound measured with the sound sensor 252 contains a frequency component that is not detected under normal conditions. As a reference value, data in the same operation status as the measured value is used.

[0042]

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

[0043]

Next, an abnormality detection process of the elevator device 10 is described with reference to a flowchart illustrated in Fig. 7. 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).

[0044]

The reference values are acquired before the elevator device 10 is operated (Step S11). In detail, the value of the drive current of the pump 220 under normal conditions, the water pressure value under normal conditions, the value of the flow rate of water under normal conditions, the value of vibration produced by the pump 220 under normal conditions, and the value of sound produced by the pump 220 under normal conditions are acquired as reference values and stored in the storage unit 722. The reference values are acquired under conditions in which the combination of parameters of the load weight of the cage 31, the travel distance, the frequency of cage operation, and the environmental temperature measured with the 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 of the cage 31, the travel distance, and the frequency of cage operation. 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 of the cage 31, the travel distance, and the frequency of cage operation, 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.

[0045]

Once the elevator device 10 starts to operate, the operation status monitoring unit 721 monitors the operation status by monitoring the output power of the inverter 93 (for example, the output power per hour) (Step S12).

[0046]

The abnormality detection device 72 monitors whether or not the ascent or

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

[0047]

When the ascent or descent operation of the cage 31 has been performed (Step S13: Yes), the abnormality detecting unit 723 acquires data indicating the state of the water-cooled cooling system 200 (Step S14). The data indicating the status of the water-cooled cooling system 200 includes the value of the drive current of the pump 220 measured with the current sensor 250, the value of vibration of the pump 220 acquired by the vibration sensor 251, the value of sound of the pump 220 acquired by the sound sensor 252, the water pressure value in the pipes 210 acquired by the water pressure sensor 253, and the value of the flow rate of water flowing through the pipes 210 acquired by the water flow sensor 254.

[0048]

Next, 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 information on the environmental temperature from the temperature sensor 38 (Step S15). 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.

[0049]

Next, the abnormality detecting unit 723 extracts from the storage unit 722 the reference values corresponding to the parameters of the load weight of the cage 31, the travel distance of the cage 31, the operating status, and the environment temperature

acquired by the operation status monitoring unit 721 in Step S15. Then, the abnormality detecting unit 723 determines whether or not there is an abnormality in the water-cooled cooling system 200 by comparing the data indicating the state of the water-cooled cooling system 200 acquired in Step S14 with the reference values (Step S16).

[0050]

The abnormality detecting unit 723 compares the measured value of the drive current of the pump 220, the measured value of the water pressure, the measured value of the flow rate of water, the measured value of vibration, and the measured value of sound measured each time the cage 31 ascends or descends with the respective reference values, and determines that an abnormality has occurred in the water-cooled cooling system 200 when the difference between the measured value and the reference value exceeds a predetermined value (Step S16: Yes). The abnormality detecting unit 723 determines that an abnormality has occurred in the water-cooled cooling system 200 even when it detects in the measured vibration and sound data a frequency component that is not included under normal conditions.

[0051]

Next, the abnormality detecting unit 723 estimates a cause of damage to the water-cooled cooling system 200 based on the measurement results of various sensors (Step S17). The abnormality detecting unit 723 compares at least one of the measured value of the drive current of the pump 220, the measured water pressure value in the pipes 210, the measured value of the flow rate of water flowing through the pipes 210, the measured value of vibration produced by the water-cooled cooling system 200, and the measured value of sound produced by the water-cooled cooling system 200, which are measured each time the cage 31 ascends or descends, with the reference value, and detects that an abnormality has occurred in the water-cooled cooling system 200 when the

difference between the measured value and the reference value exceeds a predetermined value.

[0052]

Fig. 8 is a table illustrating the relationship between a sensor that measured an abnormal value and a cause of damage to the water-cooled cooling system 200. For example, when the measured value of the current sensor 250 or the water flow sensor 254 is an abnormal value, damage to a pump motor and damage to the pipes 210 or the tank 240 are considered. In addition, when the measured value of the vibration sensor 251 or the sound sensor 252 is an abnormal value, damage to the pump motor is considered. As for damage to the pump motor, a bearing part often suffers damage. When the measured value of the water pressure sensor 253 is an abnormal value, damage to the pipes 210 or the tank 240 is considered.

[0053]

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 controls the ascent and descent of 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 the ascent/descent speed of the cage 31 are reduced compared to the normal operations. By operating the cage 31 in the safety mode, the amount of heat generated by the inverter 93 can be suppressed, and damage to the inverter 93 before a safety check is conducted can be suppressed. The safety mode includes stopping the cage 31 on the nearest floor and stopping the ascent or descent operation of the cage 31 until the safety check is completed.

[0054]

As described above, the elevator abnormality detection device 72 according to

the embodiment compares the measured values (the measured value of the drive current of the pump 220, the measured water pressure value, the measured value of the flow rate, the measured value of vibration, and the measured value of sound) measured each time the cage 31 ascends or descends with the reference value (the value of the drive current of the pump 220, the water pressure value, the value of the flow rate, the value of vibration, and the value of sound under normal conditions), and detects that an abnormality has occurred in the water-cooled cooling system 200 when the difference between the measured value and the reference value exceeds a predetermined value. This allows the elevator abnormality detection device 72 according to the embodiment to enhance the accuracy of detecting damage to the water-cooled cooling system 200 used in the elevator device.

[0055]

In addition, the elevator abnormality detection device 72 according to the embodiment can estimate a cause of damage to the water-cooled cooling system 200 by comparing the measured values of the drive current of the pump 220, the water pressure, the flow rate of water, vibration, and sound, which are measured each time the cage 31 ascends or descends, with the reference values (the value of the drive current of the pump 220, the water pressure value, the value of the flow rate, the value of vibration, and the value of sound under normal conditions).

[0056]

Further, the elevator abnormality detection device 72 according to the embodiment has a reference value according to the load weight, travel distance, frequency of cage operation, and environmental temperature, makes a comparison with the reference value according to the load weight, travel distance, frequency of cage operation, and environmental temperature to detect that an abnormality has occurred in the water-cooled

cooling system 200, and estimate the cause of damage to the water-cooled cooling system 200. Since the elevator abnormality detection device 72 according to the embodiment makes a comparison with the temperature under normal conditions considering the parameter conditions categorized in detail, the accuracy of detecting damage to the water-cooled cooling system 200 used in the elevator device can be enhanced, and the accuracy of estimating the cause of damage to the water-cooled cooling system 200 can be improved.

[0057]

In the above description, a case has been described in which the current sensor 250, the vibration sensor 251, the sound sensor 252, the water pressure sensor 253, and the water flow sensor 254 are provided as sensors that detect an abnormality in the water-cooled cooling system 200. However, any of these sensors can be omitted. One sensor or a plurality of sensors may be omitted.

[0058]

When the cage 31 ascends or descends, it reaches a constant speed after accelerating from a standstill and decelerates before stopping. Since the output current of the inverter 93 is at its maximum during this acceleration, the temperature measured with the temperature sensor 97 is also at its maximum during this acceleration. The flow rate of water driven by the pump 220 can also be controlled according to this temperature change. In this case, the drive current of the pump 220 is at its maximum when the cage 31 is accelerated. For the above-described determination of abnormality detection based on the drive current of the pump 220, a comparison may be made focusing on the maximum drive current value, a comparison may be made with the drive current when the cage 31 is at a constant speed, or a comparison may be made with the average value for one ascent or descent.

[0059]

In addition, in the above description, a case has been described in which the drive current of the pump 220 is measured with the current sensor 250 and the vibration sensor 251 and the sound sensor 252 are arranged near the pump 220. Furthermore, by measuring the drive current of the radiator 230 with a current sensor and arranging a vibration sensor and a sound sensor near the radiator 230, information for estimating damage to the radiator 230 can be acquired. Thus, by arranging a sensor for each component part of the water-cooled cooling system 200, the accuracy of estimating the cause of damage can be improved.

[0060]

Moreover, in the above description, a case has been described in which, by controlling the pump motor control unit 222 according to the operation status of the cage 31, the drive unit control unit 71 controls the flow rate of water caused to flow by the pump 220 so that the temperature of the heating elements 921 of the inverter 93 is equal to or lower than a predetermined temperature. Some simple water-cooled cooling systems keep the flow rate of water caused to flow by the pump 220 constant regardless of the operation status of the cage 31. In addition, some omit the tank 240, and others omit the radiator 230.

[0061]

Regular periodic inspections of elevator devices are carried out every few months. For example, when a crack occurs in the pipes 210 of the water-cooled cooling system 200, the water in the pipes 210 and the tank 240 is depleted before the next periodic inspection, reducing the cooling effect. In this case, the inverter 93 is more likely to suffer damage because 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 car 31, or on a daily basis, such as at night.

[0062]

(Modification 1)

In the above description, a case of passing water as a cooling medium through the pipes 210 has been described. However, the medium that cools the heat sink 300 does not need to be limited to water. For example, various kinds of gases called chlorofluorocarbons used in air conditioners may be acceptable. In this case, for example, 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.

[0063]

(Embodiment 2)

In the description of Embodiment 1, a technique has been described in which the accuracy of estimating the cause of damage is improved by arranging a sensor for each component part of the water-cooled cooling system 200. There are other methods for estimating the cause of damage. For example, the cause of damage can be estimated from the frequency component of noise superimposed on the current waveform measured with the current sensor 250.

[0064]

The pump 220 and the radiator 230 constituting the water-cooled cooling system 200 have resonant frequencies depending on their respective operating speeds, sizes, and shapes. The pipes 210 and the tank 240 also have resonant frequencies depending on their respective sizes and shapes. When an abnormality occurs in each component part of the water-cooled cooling system 200, these resonant frequencies also change. For

example, when a brush of the pump motor is worn, the contact resistance of a worn part is different from the contact resistance of an unworn part, resulting in noise caused by the difference in the contact resistance. The frequency component of this noise is a frequency component that does not exist under normal conditions. In addition, when a crack occurs in the pipes 210, the resonance frequency of the pipes 210 changes. Therefore, the frequency of the superimposed noise also changes.

[0065]

The noise caused by these resonant frequencies is superimposed on the current waveform measured with the current sensor 250. By making a comparison with the frequency component of the superimposed noise (the distribution of the frequency spectrum) when all the component parts of the water-cooled cooling system 200 are normal, it is also possible to estimate in which component part of the water-cooled cooling system 200 an abnormality has occurred.

[0066]

While some embodiments of the present invention have been described, these embodiments have been presented by way of example, and are not intended to limit the scope of the invention. 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

[0067]

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	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	storage 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
222	pump motor control unit
230	radiator
240	tank
250	current sensor
251	vibration sensor
252	sound sensor
253	water pressure sensor
254	water flow sensor
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, wherein

the water-cooled cooling system includes:

a pipe internally containing water as a refrigerant and cooling a heat sink that cools the power supply;

a pump causing water flowing through the pipe to flow; and

a radiator that cools water flowing through the pipe, and

the elevator abnormality detection device comprises:

at least one sensor among a current sensor that measures a current to drive the pump, a water pressure sensor that measures water pressure of water flowing through the pipe, a water flow sensor that measures flow rate of water flowing through the pipe, a vibration sensor that measures vibration produced by the pump or the radiator, and a sound sensor that measures sound produced by the pump or the radiator;

a storage unit that stores at least one of a value of drive current of the pump under normal conditions, a water pressure value in the pipe under normal conditions, a value of flow rate of water flowing through the pipe under normal conditions, a value of vibration produced by the water-cooled cooling system under normal conditions, and a value of sound produced by the water-cooled cooling system under normal conditions as a reference value; and

an abnormality detecting unit that compares at least one of a measured value of drive current, a measured water pressure value in the pipe, a measured value of flow rate of water flowing through the pipe, a measured value of vibration produced by the water-cooled cooling system, and a measured value of sound produced by the water-

cooled cooling system, with the reference value, and detects that an abnormality has occurred in the water-cooled cooling system when a difference between the measured value and the reference value exceeds a predetermined value, the measured values being measured each time the cage ascends or descends.

2. 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, wherein

the water-cooled cooling system includes:

a pipe internally containing water as a refrigerant and cooling a heat sink that cools the power supply; and

a pump causing water flowing through the pipe to flow, and

the elevator abnormality detection device comprises:

a current sensor that measures a current to drive the pump;

a storage unit that stores a value of drive current of the pump under normal conditions as a reference value; and

an abnormality detecting unit that compares a measured value of drive current of the pump measured with the current sensor each time the cage ascends or descends with the reference value, and detects that an abnormality has occurred in the water-cooled cooling system when a difference between the measured value and the reference value exceeds a predetermined value.

3. 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, wherein

the water-cooled cooling system includes:

a pipe internally containing water as a refrigerant and cooling a heat sink that cools the power supply; and

a pump causing water flowing through the pipe to flow, and

the elevator abnormality detection device comprises:

a water pressure sensor that measures water pressure of water flowing through the pipe;

a storage unit that stores a water pressure value in the pipe under normal conditions as a reference value; and

an abnormality detecting unit that compares a measured value of water pressure in the pipe measured with the water pressure sensor each time the cage ascends or descends with the reference value, and detects that an abnormality has occurred in the water-cooled cooling system when a difference between the measured value and the reference value exceeds a predetermined value.

4. 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, wherein

the water-cooled cooling system includes:

a pipe internally containing water as a refrigerant and cooling a heat sink that cools the power supply; and

a pump causing water flowing through the pipe to flow, and

the elevator abnormality detection device comprises:

a water flow sensor that measures flow rate of water flowing through the pipe;

a storage unit that stores flow rate of water flowing through the pipe under normal conditions as a reference value; and

an abnormality detecting unit that compares a measured value of flow rate of water flowing through the pipe measured with the water flow sensor each time the cage ascends or descends with the reference value, and detects that an abnormality has occurred in the water-cooled cooling system when a difference between the measured value and the reference value exceeds a predetermined value.

5. 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, wherein

the water-cooled cooling system includes:

a pipe internally containing water as a refrigerant and cooling a heat sink that cools the power supply;

a pump causing water flowing through the pipe to flow; and

a radiator that cools water flowing through the pipe, and

the elevator abnormality detection device comprises:

a vibration sensor that measures vibration produced by the pump or the radiator;

a storage unit that stores a value of vibration produced by the water-cooled cooling system under normal conditions as a reference value; and

an abnormality detecting unit that compares a measured value of vibration produced by the water-cooled cooling system measured with the vibration sensor each time the cage ascends or descends with the reference value, and detects that an abnormality has occurred in the water-cooled cooling system when a difference

between the measured value and the reference value exceeds a predetermined value.

6. 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, wherein

the water-cooled cooling system includes:

a pipe internally containing water as a refrigerant and cooling a heat sink that cools the power supply;

a pump causing water flowing through the pipe to flow; and

a radiator that cools water flowing through the pipe, and

the elevator abnormality detection device comprises:

a sound sensor that measures sound produced by the pump or the radiator;

a storage unit that stores a value of sound produced by the water-cooled cooling system under normal conditions as a reference value; and

an abnormality detecting unit that compares a measured value of sound produced by the water-cooled cooling system measured with the sound sensor each time the cage ascends or descends with the reference value, and detects that an abnormality has occurred in the water-cooled cooling system when a difference between the measured value and the reference value exceeds a predetermined value.

7. The elevator abnormality detection device according to any one of claims 1 to 6, wherein

the storage unit has a reference value according to load weight, travel distance, frequency of cage operation, and environmental temperature, and

the abnormality detecting unit makes a comparison with a reference value according to load weight, travel distance, frequency of cage operation, and environmental temperature to detect that an abnormality has occurred in the water-cooled cooling system.

8. The elevator abnormality detection device according to claim 7, wherein power per unit time supplied by the power supply to the motor that drives ascent and descent of the cage is used as an indicator that indicates an operating state of the cage, including load weight of the cage, travel distance, and frequency of cage operation.

9. The elevator abnormality detection device according to any one of claims 1 to 6, wherein

the abnormality detecting unit estimates a cause of damage to the water-cooled cooling system by comparing at least one of a measured value of drive current, a measured water pressure value in the pipe, a measured value of flow rate of water flowing through the pipe, a measured value of vibration produced by the water-cooled cooling system, and a measured value of sound produced by the water-cooled cooling system with the reference value, the measured values being measured each time the cage ascends or descends.

10. The elevator abnormality detection device according to any one of claims 1 to 6, further comprising

a temperature sensor that measures temperature of a heating element constituting the power supply, wherein

the pump causes water flowing through the pipe to flow such that a temperature measured with the temperature sensor is a predetermined temperature.

11. The elevator abnormality detection device according to any one of claims 1 to 6, wherein

when the abnormality detecting unit detects that an abnormality has occurred in the water-cooled cooling system, the abnormality detecting unit notifies a control unit that controls the motor that drives ascent and descent of the cage that an abnormality has occurred, and

the control unit performs ascent and descent control of the cage that limits a current required for the ascent and descent of the cage.