

ELEVATOR

Technical Field

The present invention relates to an elevator.

Background

An elevator is provided with a door control motor that drives opening and closing of the elevator door. When the operation of the door control motor is abnormal, the temperature of the coil of the door control motor will rise excessively. To ensure the safety of the elevator and to grasp the operation condition of the door control motor, it is necessary to monitor the temperature rise of the coil.

With the development of society, there are more and more high-rise buildings, which must be equipped with elevators. Safety of the elevators is getting more and more attention, but due to the number of maintenance personnel, and the limited operating capacity and testing tools, there are many security risks if the increase in motor temperature cannot be monitored in real-time. In a case where the elevator runs in the severe environments such as high temperature, the temperature of the elevator door control motor coils rises close to the most severe design conditions, and hence the elevator system, the door control system and the remote monitoring system cannot monitor the temperature of the temperature-rise coil of the motor in real time, and cannot prompt the operator and the monitoring personnel that the temperature of the door control motor rises too high to protect the door control motor.

In the prior art, there are generally three methods for detecting the motor temperature rise: the first one is a thermometer patch method, wherein the thermometer is attached to the surface of the electrode to measure the temperature; the second is a thermometer embedment method, wherein when assembling the thermometer is embedded in a place where the possible higher temperature is expected; and the third one is an infrared detection method based on image processing technology, which uses infrared thermal imagers for collecting images and transmits the same to a computer for executing the image processing and diagnosis.

However, in the thermometer patch method, there is a problem that the measurement accuracy is low. In the thermometer embedment method, it is necessary to embed the temperature-rise detection lines for the motor coil, thus increasing the cost. Further, it is only possible to measure the temperature rise during the temperature rise tests, and each of

the manufactured motors cannot be protected in real time. In addition, in the infrared detection method, a large number of calculations are required, and there exists such a problem that the calculation load is excessive.

Contents of the Invention

One object of the present invention is to solve the problems in the motor temperature rise detection methods in the prior art, and to provide an elevator capable of monitoring the operating condition of the door control motor in real time in a simple manner by means of real-time calculation of the temperature-rise values of the door control motor coil by a resistance method.

The elevator of the invention comprises: a door control motor, which drives opening and closing of a door of the elevator and has star-connected coils; and a door control board, which controls the driving of the door control motor, and has a temperature-rise monitoring mechanism for monitoring a coil temperature of the door control motor, the temperature-rise monitoring mechanism comprising: a coil initial temperature acquiring unit, which obtains a temperature of the coils as coil initial temperature before the door control motor starts to operate; a voltage measuring unit, which is connected to the door control motor to measure a phase voltage of each phase of the coils of the door control motor; a current measuring unit, which is connected to the door control motor to measure phase current of each phase of the coils of the door control motor in synchronization with measurement of the phase voltage; a coil initial resistance value calculation unit, which is connected to the voltage measuring unit and the current measuring unit and which, before the door control motor starts to operate and in a state where operation of the door control motor is stopped, calculates a resistance value of the coils as a coil initial resistance value according to the measured phase voltage and phase current of the coils; a coil real-time resistance value calculation unit, which is connected to the voltage measuring unit and the current measuring unit and which, after the door control motor has been operated for a predetermined period of time and in a state where the door is completely closed, calculates a coil real-time resistance value according to the measured phase voltage and phase current of the coils; a temperature rise calculation unit, which is connected to the coil initial temperature acquiring unit, the coil initial resistance value calculation unit and the coil real-time resistance value calculation unit, and which calculates a temperature rise value of the coils according to the coil initial temperature, the coil initial resistance value and the coil real-time resistance value by using a resistance method, the temperature-rise

monitoring mechanism monitoring the coil temperature of the door control motor in real time according to the temperature rise value.

In accordance with the elevator of the invention, the temperature-rise monitoring mechanism further comprises: a comparison unit, which is connected to the temperature rise calculation unit and compares the temperature rise value from the temperature rise calculation unit with a preset temperature upper limit value; and a warning unit, which is connected to the comparison unit and issues a warning when the comparison result of the comparison unit is that the temperature rise value exceeds the temperature upper limit value.

In accordance with the elevator of the invention, the elevator is provided with an operation mechanism enabling the user to perform various inputs, and the coil initial temperature acquiring unit is connected to the operation mechanism and acquires a specified temperature value inputted by the user through the operation mechanism as the coil initial temperature.

In accordance with the elevator of the invention, provided on the door control board is a temperature sensor that is connected to the door control motor and measures temperature of the coils of the door control motor, and the coil initial temperature acquiring unit reads the temperature value of the temperature sensor as the coil initial temperature before the door control motor starts to operate.

In accordance with the elevator of the invention, the elevator is provided with a remote monitoring mechanism, which is connected to the temperature-rise monitoring mechanism to remotely monitor the coil temperature of the door control motor.

In accordance with the elevator of the invention, the temperature upper limit value is predetermined according to the temperature levels of the motor.

According to the initial temperature of the door control motor coils and the voltage value and current value of each phase obtained from the motor coils in real time, the temperature rise value of the door control motor coils is calculated in real time using a resistance method. If the motor temperature rise value exceeds the preset temperature upper limit value, a fault warning is issued, and in this way, the real-time monitoring can be made in a simple manner to prevent the temperature rise from being too high to damage the door control motor, so as to meet the requirement of protecting the door control motor.

Description of the Drawings

FIG. 1 is a block diagram illustrating an overall configuration of a door control

circuit of an elevator of the present invention.

FIG. 2 is a block diagram illustrating the configuration of a temperature-rise monitoring unit provided on the door control board of the elevator of the present invention.

FIG. 3 is a circuit diagram of a motor control system of the elevator of the present invention.

FIG. 4 is a flow chart for monitoring the temperature rise of the door control motor of the elevator of the present invention.

Embodiments

Hereinafter, the embodiments of the invention will be described in detail with reference to the accompanying drawings.

As shown in FIG. 1, the elevator comprises: a door control motor 1, which drives opening and closing of a door of the elevator and has star-connected coils as illustrated in FIG. 3; and a door control board 2, which controls the driving of the door control motor 1, and has a temperature-rise monitoring mechanism 3 for monitoring a coil temperature of the door control motor.

As shown in FIG. 2, the temperature-rise monitoring mechanism comprises a coil initial temperature acquiring unit 31, a voltage measuring unit 32, a current measuring unit 33, a coil initial resistance value calculation unit 34, a coil real-time resistance value calculation unit 35, and a temperature rise calculation unit 36. The temperature rise calculation unit 36 calculates a temperature rise value of the coils by using a resistance method based on the coil initial temperature acquired by the coil initial temperature acquiring unit 31, the coil initial resistance value calculated by the coil initial resistance value calculation unit, and the coil real-time resistance value calculated by the coil real-time resistance value calculation unit 35. The temperature-rise monitoring mechanism 3 monitors temperature of the coils of the door control motor in real time according to the temperature rise value.

Concretely, as shown in FIG. 1, the elevator further comprises an operation mechanism 4 enabling the user to perform various inputs, and the coil initial temperature acquiring unit 31 is connected to the operation mechanism 4 and acquires the temperature of the coils as coil initial temperatures T_{u1} , T_{v1} , T_{w1} before the door control motor starts to run. Furthermore, although not shown, the door control board may be provided with a temperature sensor (not shown) that is connected to the door control

motor and measures the temperature of the coils of the door control motor. The coil initial temperature acquiring unit 31 also can read temperature values of the temperature sensor as the coil initial temperatures Tu1, Tv1, Tw1, before the door control motor starts to run.

Further, as shown in FIG. 2, in the temperature-rise monitoring mechanism 3, the voltage measuring unit 32 is connected to the door control motor 1 to measure a phase voltage of each phase of the coils of the door control motor 1, and the current measuring unit 33 is connected to the door control motor 1 to measure phase current of each phase of the coils of the door control motor 1 in synchronization with measurement of the phase voltage.

Furthermore, the coil initial resistance value calculation unit 34 is connected to the voltage measuring unit 32 and the current measuring unit 33. Further, before the door control motor 1 starts to operate and in a state where operation of the door control motor 1 is stopped, the coil initial resistance value calculation unit calculates resistance values of the coils as coil initial resistance values Ru1, Rv1, Rw1 according to the phase voltage and phase current of the coils by using the relationship: resistance value = voltage/current.

Furthermore, the voltage measuring unit 32 is connected to the door control motor 1, and measures phase voltages Uu, Uv, Uw of each phase of the coils of the door control motor in real time in a state where the door is completely closed, after the door control motor 1 has been operated for a predetermined period of time. Specifically, Uu, Uv, Uw are obtained according to the inter-PN voltages VuC, VvC, VwC based on the following Expression (1).

$$\begin{aligned} U_u &= \frac{V_{uC}}{4000h} * VDC * \frac{1}{2 * \sqrt{2}} \\ U_v &= \frac{V_{vC}}{4000h} * VDC * \frac{1}{2 * \sqrt{2}} \\ U_w &= \frac{V_{wC}}{4000h} * VDC * \frac{1}{2 * \sqrt{2}} \end{aligned}$$

Expression (1)

In this way, it is well-known in the art that the voltages of the respective phases of the coils are obtained according to the inter-PN voltages VuC, VvC, VwC by using the Expression (1), and thus detailed description thereof will be omitted.

Further, the current measuring unit 33 is connected to the door control motor 1, and measures phase currents IvF, IuF, IwF of the respective phases of the coils from the door control motor in synchronization with measurement of the phase voltages by the voltage

measuring unit 32, wherein according to the circuit diagram of FIG. 3, in the motor coils, the coil current satisfies the relationship of $I_vF + I_uF + I_wF = 0$, and thus it is only necessary to measure any two of them.

Moreover, the coil real-time resistance value calculation unit is connected to the voltage measuring unit and the current measuring unit, and calculates a coil real-time resistance value based on the phase voltage and phase current measured after the door control motor has been operated for a predetermined period of time and in a state where the door is completely closed. Specifically, the coil real-time resistance values R_{u2} , R_{v2} , and R_{w2} are calculated by the following Expression 2.

$$R_u = \frac{U_u}{I_uF} \quad R_v = \frac{U_v}{I_vF} \quad R_w = \frac{U_w}{I_wF}$$

Expression 2

Further, the temperature rise calculation unit is connected to the coil initial temperature acquiring unit, the coil initial resistance value calculation unit and the coil real-time resistance value calculation unit, and calculates temperature rise values T_{u2} , T_{v2} , T_{w2} of the coils according to the coil initial temperatures T_{u1} , T_{v1} , T_{w1} from the coil initial temperature acquiring unit, the coil initial resistance values R_{u1} , R_{v1} , R_{w1} from the coil initial resistance value calculation unit, and the coil real-time resistance values R_{u2} , R_{v2} , R_{w2} from the coil real-time resistance value calculation unit, by using a resistance method. Specifically, the temperature rise values are calculated by the following Expression 3.

$$T_{u2} = \left(\frac{R_{u2}}{R_{u1}} - 1 \right) * (234.5 + T_{u1})$$

$$T_{v2} = \left(\frac{R_{v2}}{R_{v1}} - 1 \right) * (234.5 + T_{v1})$$

$$T_{w2} = \left(\frac{R_{w2}}{R_{w1}} - 1 \right) * (234.5 + T_{w1})$$

Expression 3

In this way, it is a well-known technique in the art that the temperature rise values of coils are calculated according to the coil initial temperatures and the coil initial resistance values, and thus detailed description thereof will be omitted.

Further, in the elevator of the present invention, the temperature-rise monitoring mechanism further comprises: a comparison unit 37, which is connected to the

temperature rise calculation unit 36 and compares the temperature rise value from the temperature rise calculation unit 36 with a preset temperature upper limit value; and a warning unit 38, which is connected to the comparison unit 37 and issues a warning when the comparison result of comparison unit 37 is that the temperature rise value exceeds the temperature upper limit value. Here, as an example, the temperature upper limit value is set in advance according to the temperature levels of the motor.

Moreover, the elevator of the present invention further comprises a remote monitoring mechanism 5, which is connected to the temperature-rise monitoring mechanism to remotely monitor the coil temperature of the door control motor. Further, when the temperature rise value exceeds the temperature upper limit value, the elevator control system takes the control to stop the operation of the motor. Hereby, it is possible to prevent the door control motor from being damaged due to the excessive high temperature.

Next, the operations when the user operates using the elevator of the present invention will be briefly described.

In step S1, before the door control motor starts to run, i.e., in a state where operation of the motor is stopped, the user such as the elevator administrator operates the operating mechanism, and sets a coil temperature initial value of the door control motor according to the ambient temperature, or the coil initial temperature acquiring unit directly reads the coil temperature initial value from the temperature sensor on the door control board.

Next, in step S2, before the door control motor starts to run, i.e., in a state where operation of the motor is stopped, the phase voltage and phase current of the motor coils are measured, and the resistance value of the coils is calculated as the coil initial resistance value.

Next, in step S3, it is judged whether or not the door position learning is completed and the door is completely closed. If the determination in step S3 is YES, the operation proceeds to step S4.

Next, in step S4, the phase voltages of the respective phases of the coils are acquired.

Next, in step S5, the phase currents of the respective phases of the coils are obtained in synchronization with acquisition of the phase voltages.

Next, in step S6, the coil real-time resistance value is calculated based on the phase voltages and the phase currents.

Next, in step S7, the temperature rise value of the coil is calculated by a resistance method based on the coil initial temperature obtained in step S1, the coil initial resistance

value obtained in step S2, and the coil real-time resistance value obtained in step S6.

Next, in step S8, it is determined whether or not the temperature rise value calculated in step S7 exceeds a preset temperature upper limit value.

Next, in step S9, when the determination in step S8 is YES, a warning is issued.

According to the elevator of the present invention, the temperature rise value of the door motor coil is calculated by the resistance method, and it is possible to monitor the operation states of the door control motor in real time by a simple configuration, so as to prevent the motor coils from being damaged due to too high temperature rise.

Although the embodiments of the invention have been described above, the embodiments are provided by way of example only and are not intended to limit the scope of the invention. New embodiments can be carried out in other various ways, and various omissions, substitutions and changes can be made without departing from the scope of the invention. These embodiments and their modifications are intended to be included within the scope and spirit of the invention, and also within the scope of the appended claims and their equivalents.

CLAIMS

1. An elevator, characterized by comprising:

a door control motor, which drives opening and closing of a door of the elevator and has star-connected coils; and

a door control board, which controls the driving of the door control motor, and has a temperature-rise monitoring mechanism for monitoring a coil temperature of the door control motor,

the temperature-rise monitoring mechanism comprising:

a coil initial temperature acquiring unit, which obtains a temperature of the coils as coil initial temperatures T_{u1} , T_{v1} , T_{w1} before the door control motor starts to operate;

a voltage measuring unit, which is connected to the door control motor to measure a phase voltages U_u , U_v , U_w of each phase of the coils of the door control motor;

a current measuring unit, which is connected to the door control motor to measure phase currents I_{vF} , I_{uF} , I_{wF} of each phase of the coils of the door control motor in synchronization with measurement of the phase voltage;

a coil initial resistance value calculation unit, which is connected to the voltage measuring unit and the current measuring unit and which, before the door control motor starts to operate and in a state where operation of the door control motor is stopped, calculates a resistance value of the coils as coil initial resistance values R_{u1} , R_{v1} , R_{w1} according to the measured phase voltage and phase current of the coils by the following Expression 1,

Expression 1 : $R_{u1}=U_u/I_{uF}$, $R_{v1}=U_v/I_{vF}$, $R_{w1}=U_w/I_{wF}$;

a coil real-time resistance value calculation unit, which is connected to the voltage measuring unit and the current measuring unit and which, after the door control motor has been operated for a predetermined period of time and in a state where the door is completely closed, calculates coil real-time resistance values R_{u2} , R_{v2} , R_{w2} according to the measured phase voltage and phase current of the coils by the following Expression 2,

Expression 2 : $R_{u2}=U_u/I_{uF}$, $R_{v2}=U_v/I_{vF}$, $R_{w2}=U_w/I_{wF}$;

a temperature rise calculation unit, which is connected to the coil initial temperature acquiring unit, the coil initial resistance value calculation unit and the coil real-time resistance value calculation unit, and which calculates a temperature rise value of the coils according to the coil initial temperature, the coil initial resistance value and the

coil real-time resistance value by using a resistance method, the temperature rise values Tu_2, Tv_2, Tw_2 are calculated by the following Expression 3,

Expression 3 : $Tu_2 = ((Ru_2/Ru_1) - 1) * (234.5 + Tu_1)$, $Tv_2 = ((Rv_2/Rv_1) - 1) * (234.5 + Tv_1)$,
 $Tw_2 = ((Rw_2/Rw_1) - 1) * (234.5 + Tw_1)$,

the temperature-rise monitoring mechanism monitoring the coil temperature of the door control motor in real time according to the temperature rise value.

2. The elevator as claimed in claim 1, characterized in that,

the temperature-rise monitoring mechanism further comprises:

a comparison unit, which is connected to the temperature rise calculation unit and compares the temperature rise value from the temperature rise calculation unit with a preset temperature upper limit value; and

a warning unit, which is connected to the comparison unit and issues a warning when the comparison result of the comparison unit is that the temperature rise value exceeds the temperature upper limit value.

3. The elevator as claimed in claim 1, characterized in that,

the elevator is provided with an operation mechanism enabling the user to perform various inputs,

the coil initial temperature acquiring unit is connected to the operation mechanism and acquires a specified temperature value inputted by the user through the operation mechanism as the coil initial temperature.

4. The elevator as claimed in claim 1, characterized in that,

provided on the door control board is a temperature sensor, which is connected to the door control motor and measures temperature of the coils of the door control motor,

the coil initial temperature acquiring unit reads the temperature value of the temperature sensor as the coil initial temperature before the door control motor starts to operate.

5. The elevator as claimed in claim 3 or 4, characterized in that,

the elevator is provided with a remote monitoring mechanism, which is connected to the temperature-rise monitoring mechanism to remotely monitor the coil temperature of the door control motor.

6. The elevator as claimed in claim 1, characterized in that,
the temperature upper limit value is set in advance according to the temperature levels of the motor.