United States Patent Application Publication	20250260356
Kind Code	A1
Publication Date	August 14, 2025
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DRIVE DEVICE

Abstract

The drive device includes a motor, an inverter that drives the motor, a power storage device that is connected to the inverter via a power line, a cooling device that circulates coolant in a circulation flow path that includes the motor, the inverter, and the power storage device, and a control device that controls the inverter and the cooling device. The control device controls the inverter so that the d-axis current flowing through the motor becomes smaller when the temperature of the coolant is less than the first temperature threshold value compared to when the temperature of the coolant is equal to or higher than the first temperature threshold value when executing the temperature rise d-axis control for controlling the inverter so that only the d-axis current flows through the motor along with operation of a cooling device in accordance with the temperature rise request of the power storage device.

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Appl. No.: **18/963556**

Filed: **November 28, 2024**

Foreign Application Priority Data

JP	2024-018436	Feb. 09, 2024

Publication Classification

Int. Cl.: **H02P29/68** (20160101); **H02P27/06** (20060101)

U.S. Cl.:

CPC H02P29/68 (20160201); H02P27/06 (20130101);

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Japanese Patent Application No. 2024-018436 filed on Feb. 9, 2024, incorporated herein by reference in its entirety.

BACKGROUND

1. Technical Field

[0002] The present disclosure relates to a drive device.

2. Description of Related Art

[0003] There has conventionally been proposed a drive device including a motor, an inverter that drives the motor, a power storage device connected to the inverter via a power line, and a capacitor attached to the power line, in which switching control of the inverter is performed such that a d-axis current flows between the power storage device and the motor when it is necessary to raise the temperature of the power storage device (see Japanese Unexamined Patent Application Publication No. 2023-038755 (JP 2023-038755 A), for example). In this drive device, the temperature of the power storage device is raised by charging and discharging the power storage device by increasing and reducing the d-axis current using the resonance between inductance components in the power storage device, the power line, the inverter, and the conductive member of the motor and the capacitor.

SUMMARY

[0004] In a drive device including a motor, an inverter that drives the motor, a power storage device connected to the inverter via a power line, and a cooling device that circulates coolant in a circulation flow path including the motor, the inverter, and the power storage device, there is a possibility that heat generation of the motor and the inverter and thus a temperature rise becomes large with a current intensively flowing in a specific phase of the motor and the inverter when executing temperature rise d-axis control in which the inverter is controlled such that only a d-axis current flows through the motor along with operation of the cooling device according to a request to raise the temperature of the power storage device. When the temperature of the coolant is low, the viscosity of the coolant tends to be high and it is difficult for the coolant to circulate in the circulation flow path, compared to when the temperature of the coolant is high, and therefore the temperature of the battery is not easily raised, and the temperature of the motor and the inverter tends to be raised significantly.

[0005] The drive device according to the present disclosure has a main object to suppress an excessively large temperature rise of a motor or an inverter due to temperature rise d-axis control.

[0006] In order to achieve the above main object, the drive device according to the present disclosure adopts the following means.

[0007] An aspect of the present disclosure provides [0008] a drive device including: a motor; an inverter that drives the motor; a power storage device connected to the inverter via a power line; a cooling device that circulates coolant in a circulation flow path including the motor, the inverter, and the power storage device; and a control device that controls the inverter and the cooling device, in which [0009] the control device controls the inverter such that a d-axis current that flows through the motor is smaller when a temperature of the coolant is less than a first temperature threshold value than when the temperature of the coolant is not less than the first temperature threshold value when executing temperature rise d-axis control in which the inverter is controlled such that only the d-axis current flows through the motor along with operation of the cooling device according to a request to raise a temperature of the power storage device.

[0010] In the drive device according to the present disclosure, the control device controls the inverter such that the d-axis current that flows through the motor is smaller when the temperature of the coolant is less than the first temperature threshold value than when the temperature of the coolant is not less than the first temperature threshold value when executing temperature rise d-axis control in which the inverter is controlled such that only the d-axis current flows through the motor along with operation of the cooling device according to a request to raise the temperature of the power storage device. Consequently, it is possible to suppress an excessively large temperature rise of a motor or an inverter due to temperature rise d-axis control.
[0011] In the drive device according to the present disclosure (the drive device described above), the control device may control the inverter such that the d-axis current that flows through the motor is smaller when the temperature of the coolant is less than the first temperature threshold value or the temperature of the power storage device is equal to or more than a second temperature threshold value that is greater than the first temperature threshold value, than when the temperature of the coolant is not less than the first temperature threshold value and the temperature of the power storage device is less than the second temperature threshold value, when executing the temperature rise d-axis control along with the operation of the cooling device.
[0012] In the drive device according to the present disclosure (the drive device described above), the control device may set a duty so as to be smaller when the temperature of the coolant is less than the first temperature threshold value than when the temperature of the coolant is not less than the first temperature threshold value, set a d-axis current command to a product of the duty and a reference current value and sets a q-axis current command to a value 0, and control the inverter so as to cancel out a difference between the d-axis current and a q-axis current and the d-axis current command and the q-axis current command, when executing the temperature rise d-axis control.
[0013] In the drive device according to the present disclosure (any one of the drive devices described above), the drive device may be able to perform external charge in which the power storage device is charged using electric power from an external power source; and the control device may execute the temperature rise d-axis control along with the operation of the cooling device during the external charge and when the request to raise the temperature of the power storage device is made. In this manner, it is possible to suppress an excessively large temperature rise of a motor or an inverter due to temperature rise d-axis control during external charge.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0014] Features, advantages, and technical and industrial significance of exemplary embodiments of the disclosure will be described below with reference to the accompanying drawings, in which like signs denote like elements, and wherein:
[0015] FIG. **1** is a schematic configuration diagram of a battery electric vehicle **20** including a drive device of an embodiment of the present disclosure and a charging station **80**;
[0016] FIG. **2** is a flowchart illustrating an example of a processing routine;
[0017] FIG. **3** is a flowchart illustrating an example of temperature rise d-axis control;
[0018] FIG. **4** is a flow chart illustrating an exemplary current command setting process; and
[0019] FIG. **5** is an explanatory diagram illustrating an example of a state in which a temperature increase request of the battery **36** is performed during external charging.
DETAILED DESCRIPTION OF EMBODIMENTS
[0020] Embodiments for carrying out the present disclosure will be described with reference to the drawings. FIG. **1** is a schematic configuration diagram of a battery electric vehicle **20** including a drive device and a charging station **80** according to an embodiment of the present disclosure. As illustrated, battery electric vehicle **20** includes a motor **32**, an inverter **34**, a battery **36** as a power

storage device, a vehicle connector **39**, a cooling device **40**, and a vehicle electronic control unit (hereinafter referred to as "vehicle ECU") **50** as a control device.

[0021] The motor **32** is configured as a three-phase AC motor, and includes a rotor in which a permanent magnet is embedded in a rotor core, and a stator in which a three-phase coil is wound around the stator core. The rotor of the motor **32** is connected to a drive shaft **26** connected to the drive wheels **22***a*, **22***b* via a differential gear **24**.

[0022] The inverter **34** is used to drive the motor **32** and is connected to the battery **36** via a power line **37**. The inverter **34** includes transistors T**11** to T**16** as six switching elements and six diodes D**11** to D**16**. The transistors T**11** to T**16** are arranged in pairs so as to be on the source-side and the sink-side with respect to the positive-side line and the negative-side line of the power line **37**, respectively. Each of the connecting points of the transistor as a pair of transistors T**11** to T**16** is connected to each of the three phases (U-phase, V-phase, W-phase) coils of the motor **32**. The six diodes D**11** to D**16** are connected in parallel to the six transistors T**11** to T**16**. When a voltage is applied to the inverter **34**, the ratio of the on-time of the pair of transistors T**11** to T**16** is adjusted by the vehicle ECU **50**, so that a rotating magnetic field is formed in the three-phase coil, and the motor **32** is rotationally driven.

[0023] The battery **36** is configured as a lithium-ion secondary battery or a nickel-hydrogen secondary battery, and is connected to the inverter **34** via the power line **37** as described above. A smoothing capacitor **38** is attached to the power line **37**.

[0024] The vehicle connector **39** is connected to the power line **37** and is configured to be connectable to the stand connector **84** of the charging station **80**. The charging station **80** is provided at a charging point such as a home or a charging station. Battery electric vehicle **20** may charge the battery **36** using power from the charging station **80** when the vehicle connector **39** and the stand connector **84** are connected.

[0025] The cooling device **40** includes a circulation flow path **42**, a radiator **44**, and an electric pump **46**. The circulation flow path **42** is configured as a flow path for circulating the coolant to the motor **32**, the inverter **34**, the battery **36**, and the radiator **44** in this order. The electric pump **46** circulates the coolant in the circulation flow path **42**. The circulation flow path **42** may be configured as a flow path for circulating the coolant to the inverter **34**, the motor **32**, the battery **36**, and the radiator **44** in this order.

[0026] The vehicle ECU **50** includes a microcomputer having a CPU, ROM, RAM, a flash memory, an input/output port, and a communication port, various driving circuits, and various logic IC. The vehicle ECU **50** receives signals from various sensors via an input port. For example, the vehicle ECU **50** receives the rotational position θm from the rotational position sensor **32***a* that detects the rotational position of the rotor of the motor **32**, and the **20** phase currents Iu, Iv, Iw from the current sensors **32***u*, **32***v*, **32***w* that detects the phase current of each phase of the motor **32**. The vehicle ECU **50** also receives the temperature αm from the temperature sensor **32***t* attached to the motor **32** and the temperature αi from the temperature sensor **34***t* attached to the inverter **34**. The vehicle ECU **50** also receives a voltage Vb from a voltage sensor **36***v* attached between terminals of the battery **36**, a current Ib from a current sensor **36***i* attached to an output terminal of the battery **36**, and a temperature αb from a temperature sensor **36***t* attached to the battery **36**. The vehicle ECU **50** also receives the voltage VH of the capacitor **38** (power line **37**) from the voltage sensor **38***v* mounted between the terminals of the capacitor **38**, and the coolant temperature αw from the temperature sensor **48** mounted in the circulation flow path **42** of the cooling device **40**. The vehicle ECU **50** also receives a start signal from the power switch **60**, a shift position SP from the shift sensor **62** that detects the operation position of the shift lever **61**, an accelerator operation amount Acc from the accelerator pedal position sensor **64** that detects the depression amount of the accelerator pedal **63**, a brake pedal position BP from the brake pedal position sensor **66** that detects the depression amount of the brake pedal **65**, and a vehicle speed V from the vehicle speed sensor **67**.

[0027] The vehicle ECU **50** outputs various control signals via an output port. For example, the vehicle ECU **50** outputs a control signal to the transistors T**11** to T**16** of the inverter **34** and a control signal to the electric pump **46** of the cooling device **40**. The vehicle ECU **50** calculates the electric angle θe and the rotational speed Nm of the motor **32** based on the rotational position θm of the rotor of the motor **32**. The vehicle ECU **50** calculates the power storage ratio SOC of the battery **36** based on the integrated value of the current Ib of the battery **36**, and calculates the input limit Win which is the allowable input power based on the power storage ratio SOC and the temperature αb of the battery **36**. The input limit Win is set such that the absolute value decreases as the temperature αb of the battery **36** is separated from the allowable temperature range toward the lower side. The vehicle ECU **50** is capable of communicating with an electronic control unit (hereinafter referred to as a "stand ECU") **88** of the charging station **80** at a charging point.
[0028] The charging station **80** includes a power supply device **82**, a stand connector **84**, and a stand ECU **88**. The power supply device **82** is connected to the stand connector **84** via a power line **86**. The power supply device **82** is configured to convert AC power from the power system into DC power, and to adjust the output voltage and the output power so as to be able to output the AC power. The stand connector **84** is configured to be connectable to a battery electric vehicle **20** vehicle connector **39**.
[0029] The stand ECU **88** comprises a microcomputer as well as a vehicle ECU **50**. The stand ECU **88** receives signals from various sensors via input ports. For example, the stand ECU **88** receives the output voltage Vs of the power supply device **82** from the voltage sensor and the output current Is of the power supply device **82** from the current sensor. The stand ECU **88** outputs various control signals via an output port. For example, the stand ECU **88** provides a control signal to the power supply device **82**. The stand ECU **88** calculates an output power Ps based on the output voltage Vs and the output current Is. The stand ECU **88** is capable of communicating with the vehicle ECU **50**.
[0030] In battery electric vehicle **20** of the embodiment, when the vehicle connector **39** and the stand connector **84** are connected to each other during parking of the vehicle at the charging point and the charging start condition is satisfied, the power supply from the power supply device **82** of the charging station **80** is started. When the external charging, which is the charging of the battery **36** using the electric power from the power supply device **82**, is started and thereafter the charging end condition is satisfied, the electric power supply from the power supply device **82** of the charging station **80** is ended, and the external charging is ended. As the charging start condition, for example, a condition that the user instructs to start external charging is used. As the charge termination condition, for example, a condition in which the power storage ratio SOC of the battery **36** reaches a predetermined ratio Sfl near the full charge is used. In the external charging, the vehicle ECU **50** transmits, to the stand ECU **88**, a power storage ratio SOC of the battery **36**, an input limit Win, and a charging-request current Ireq based on the power consumed by the motor **32** by the temperature-raising d-axis control described later. The stand ECU **88** controls the power supply device **82** so that the output current Is becomes the charge required current Ireq.
[0031] Next, the operation of battery electric vehicle **20** of the embodiment, in particular, the operation at the time of external charge will be described. FIG. **2** is a flow chart illustrating an exemplary process performed by the vehicle ECU **50**. This routine is repeatedly executed at the time of external charging.
[0032] When the process routine of FIG. **2** is executed, the vehicle ECU **50** first determines whether or not a temperature increase request for the battery **36** has been made (S**100**). Here, the temperature increase request of the battery **36** is performed, for example, when the temperature αb of the battery **36** is equal to or lower than the threshold value αbref**1**. When it is determined that the temperature increase request of the battery **36** is not performed, the present routine is ended. In this case, the cooling device **40** and the motor **32** are stopped or held.
[0033] When it is determined that the temperature rise request of the battery **36** is being made in S**100**, the cooling device **40** is operated (S**110**), and the temperature rise d-axis control of FIG. **3** is

executed (S**120**), and this routine is ended. Here, in the operation of the cooling device **40**, the electric pump **46** is controlled so that the coolant circulates in the circulation flow path **42**. In the temperature rise d-axis control, the inverter **34** is controlled by pulse-width modulation control (PWM control) so that only the d-axis current flows through the motor **32**. Thus, without generating torque from the motor **32**, the heat of the motor **32** and the inverter **34** is transmitted to the battery **36** via the cooling device **40** (coolant), and the temperature rise of the battery **36** is promoted.

[0034] Next, the temperature rise d-axis control of FIG. **3** will be described. In the temperature increase d-axis control of FIG. **3**, the vehicle ECU **50** first calculates the currents Id, Iq of the d-axis and the q-axis by coordinate-converting the phase currents Iu, Iv, Iw of each phase of the motor **32** using the electric angle θe of the motor **32** (three-phase-two-phase conversion) d-axis and q-axis (S**200**), and sets the current commands Id*, Iq* of the d-axis and q-axis by the current command setting process of FIG. **4** (S**210**). When the currents Id, Iq of the d-axis and the q-axis and the current commands Id*, Iq* of the d-axis and the q-axis are obtained in this manner, the voltage commands Vd*, Vq* of the d-axis and the q-axis are calculated by the current feedback control so that the difference between the currents Id, Iq of the d-axis and the q-axis and the current commands Id*, Iq* of the d-axis and the q-axis are canceled out (S**220**). Subsequently, the d-axis using the electric angle θe of the motor **32**, the coordinate conversion of the voltage commands Vd*, Vq* of the q-axis (2-3 phase conversion) to calculate the phase voltage commands Vu*, Vv*, Vw of each phase (S**230**). Then, by comparing the phase voltage commands Vu*, Vv*, Vw* and the carrier wave (triangular wave) of each phase to generate a PWM signal of transistors T**11** to T**16** of the inverter **34** (S**240**), performs switching control of the transistors T**11** to T**16** using the generated PWM signal of the transistors T**11** to T**16** (S**250**), and ends the temperature rise d-axis control. In the external charging, since the motor **32** is stopped rotating, by executing the temperature increase d-axis control, the current flows concentrated in a specific phase of the motor **32** and the inverter **34**, the heat generation of the motor **32** and the inverter **34** and thus the temperature rise is likely to increase.

[0035] Next, the current command setting process of FIG. **4** will be described. In the current command setting process of FIG. **4**, the vehicle ECU **50** determines whether the coolant temperature αw is less than the threshold value αwref (S**300**), and determines whether the temperature αb of the battery **36** is greater than or equal to the threshold value αbref**2** (S**310**). Here, the threshold value αwref is a threshold value used for determining whether the environment is the first environment. The first environment is an environment in which the temperature rise of the motor **32** and the inverter **34** tends to increase, while the temperature rise of the battery **36** is difficult to progress because the viscosity of the coolant is relatively high and the coolant is difficult to circulate through the circulation flow path **42**. The threshold value αbref**2** is a threshold value used to determine whether the environment is the second environment. The second environment is an environment in which the temperature αb of the battery **36** is increased to some extent, and the temperature of the battery **36** may be gradually increased. The threshold value αbref**2** is defined as a temperature that is somewhat lower than the threshold value αbref**1** and somewhat higher than the threshold value αwref.

[0036] When it is determined in S**300** that the coolant temperature aw is equal to or higher than the threshold value αwref, and when it is determined in S**310** that the temperature αb of the battery **36** is lower than the threshold value αbref, it is determined that it is not the first environment and is not the second environment. In this instance, a relatively large predetermined value D**1** within the range of the value 1 or less is set to the duty D (S**320**), the product of the reference current value Id**1** and the duty D is set to the current command Id* of the d-axis, and the value 0 is set to the current command Iq* of the q-axis (S**350**), and the current command setting process is ended. Here, the reference current value Id**1** may be a constant value, or a value based on at least one of the temperature αb of the battery **36**, the input limit Win, and the temperatures αm, αi of the motor **32** or the inverter **34** may be used.

[0037] When it is determined in S**300** that the coolant temperature αw is less than the threshold value αwref, it is determined that the first environment, a predetermined value D**2** smaller than the predetermined value D**1** is set to the duty D (S**330**), the product of the reference current value Id**1** and the duty D to the current command Id* of the d-axis is set, and the value 0 is set to the current command Iq* of the q-axis (S**350**), and the current command setting process is ended. With such control, the current Id of the d-axis flowing through the motor **32** becomes smaller in the first environment than in the first environment and in the second environment. Therefore, it is possible to suppress the temperature rise of the motor **32** and the inverter **34** becoming excessively large in the first environment.

[0038] When it is determined in S**310** that the temperature αb of the battery **36** is equal to or higher than the threshold αbref, it is determined that the environment is the second environment, a predetermined value D**3** smaller than the predetermined value D**1** is set in the duty D (S**340**), a product of the reference current value Id**1** and the duty D is set in the current command Id* of the d-axis, and a value 0 is set in the current command Iq* of the q-axis (S**350**), and the current command setting process is ended. Here, the predetermined value D**3** may be the same as or different from the predetermined value D**2**. By such control, the current Id of the d-axis flowing through the motor **32** becomes smaller in the second environment than in the first environment and the second environment. Therefore, it is possible to suppress the temperature rise of the motor **32** and the inverter **34** in the second environment.

[0039] FIG. **5** is an explanatory diagram illustrating an example of a state in which a temperature increase request of the battery **36** is performed during external charging. In FIG. **5**, the charge required current Ireq and the power storage ratio SOC of the battery **36**, the temperature αb, the coolant temperature αw and the duty D of the cooling device **40** are illustrated. As shown in the figure, when the external charging is started (from time t**1**), a relatively small value is set to the charging required current Ireq based on the input limit Win of the battery **36** and the power storage ratio SOC. In addition, by operating the cooling device **40** and executing the temperature increase d-axis control, an increase in the coolant temperature αw and the temperature αb of the battery **36** is promoted. In the temperature increase d-axis control, since the coolant temperature αw is less than the threshold value αwref, by setting a predetermined value D**2** smaller than the predetermined value D**1** to the duty D, the coolant viscosity is relatively high when the temperature rise of the motor **32** and the inverter **34** with the temperature rise of the battery **36** is hardly progressed because it is difficult to circulate the circulation flow path **42** of the coolant is increased tends first environment, it is possible to suppress the temperature rise of the motor **32** and the inverter **34** is excessively large. Thereafter, when the temperature αb of the battery **36** becomes higher to some extent (time t**2**) and the absolute value of the input limit Win becomes larger to some extent, the charge-request current Ireq is sufficiently increased. When the coolant temperature αw reaches the threshold value αwref or more (time t**3**), the duty D is switched from the predetermined value D**2** to the predetermined value D**1**. As a result, the amount of heat generated by the motor **32** and the inverter **34** increases as compared with the case where the coolant temperature αw is less than the threshold value αwref, and the amount of increase in the coolant temperature αw and the temperature αb of the battery **36** per unit time increases. Thereafter, when the power storage ratio SOC of the battery **36** is increased to some extent (time t**4**), the charge required current Ireq is decreased. When the temperature αb of the battery **36** reaches the threshold value αbref**2** or more during the external charge (time t**5**), the duty D is switched from the predetermined value D**1** to the predetermined value D**3**. Accordingly, it is possible to suppress the temperature rise of the motor **32** and the inverter **34** in the second environment in which the temperature rise of the battery **36** may be made gentle. Then, when the power storage ratio SOC of the battery **36** reaches the predetermined ratio Sfl (time t**6**), the external charge is terminated. In some cases, the relation between the timing (time t**2**) of sufficiently increasing the charge required current Ireq and the

timing (time t**3**) of switching the duty D from the predetermined value D**2** to the predetermined value D**1** is changed. In some cases, the relation between the timing at which the charge required current Ireq starts to decrease (time t**4**) and the timing at which the temperature αb of the battery **36** reaches the threshold value αbref**2** or more (time t**5**) is changed.
[0040] In the drive device mounted on battery electric vehicle **20** of the embodiment described above, when the temperature increase d-axis control is executed together with the operation of the cooling device **40** in accordance with the temperature increase request of the battery **36** at the time of external charging, when the coolant temperature αw of the cooling device **40** is less than the threshold value αwref, the inverter **34** is controlled so that the d-axis current Id flowing through the motor **32** becomes smaller than when the coolant temperature αw is equal to or greater than the threshold value αwref.
[0041] This makes it possible to suppress the temperature rise of the motor **32** and the inverter **34** becoming excessively large in the first environment in which the temperature rise of the motor **32** and the inverter **34** tends to become large while the temperature rise of the battery **36** is difficult to progress because the viscosity of the coolant is relatively high and the coolant is difficult to circulate in the circulation flow path **42**.
[0042] Further, in the drive device mounted on battery electric vehicle **20** of the embodiment, when the temperature increase d-axis control is executed together with the operation of the cooling device **40** in accordance with the temperature increase request of the battery **36** at the time of external charging, when the temperature αb of the battery **36** is equal to or higher than the threshold value αbref**2**, the duty D is made smaller than when the temperature αb of the battery **36** is lower than the threshold value αbref. Accordingly, it is possible to suppress the temperature rise of the motor **32** and the inverter **34** in the second environment in which the temperature rise of the battery **36** may be made gentle.
[0043] In the above-described embodiment, when performing the temperature increase d-axis control during the external charging, when the temperature αb of the battery **36** is equal to or higher than the threshold αbref**2**, the duty D is made smaller than when the temperature αb of the battery **36** is less than the threshold αbref. However, the duty D may be the same regardless of whether the temperature αb of the battery **36** is equal to or higher than the threshold αbref**2**.
[0044] In the above-described embodiment, the cooling device **40** is operated and the temperature-raising d-axis control is executed while the temperature-raising request of the battery **36** is being made during the external charging. For example, the temperature rise d-axis control may be executed when the temperature rise request of the battery **36** is made between the time when the vehicle connector **39** and the stand connector **84** are connected during parking of the vehicle at the charging point and before the charging start condition is satisfied. Further, the temperature rise d-axis control may be executed when the temperature rise request of the battery **36** is being made between the time when the power switch **60** is turned on and the time when the system is started and the time when the running is started.
[0045] In the above-described embodiment, the battery **36** is used as the power storage device, but the present disclosure is not limited thereto. For example, a capacitor or the like may be used as the power storage device.
[0046] In the above-described embodiment, the drive device mounted on battery electric vehicle **20** including the motor **32**, the inverter **34**, and the battery **36** has been described, but the present disclosure is not limited thereto. For example, in addition to the hardware configuration similar to battery electric vehicle **20**, the drive device may be mounted on a hybrid electric vehicle that further includes an engine. In addition to the hardware configuration similar to battery electric vehicle **20**, the drive device may be mounted on a fuel cell electric vehicle that further includes a fuel-cell.
[0047] The correspondence between the main elements of the embodiments and the main elements of the disclosure described in the column of the means for solving the problem will be described. In

the embodiment, the motor **32** corresponds to the "motor", the inverter **34** corresponds to the "inverter", the battery **36** corresponds to the "power storage device", the cooling device **40** corresponds to the "cooling device", and the vehicle ECU **50** corresponds to the "control device".
[0048] Note that the correspondence between the main elements of the embodiment and the main elements of the disclosure described in the section of the means for solving the problem is an example for specifically explaining the embodiment of the disclosure described in the section of the means for solving the problem, and therefore the elements of the disclosure described in the section of the means for solving the problem are not limited. That is, the interpretation of the disclosure described in the section of the means for solving the problem should be performed based on the description in the section, and the embodiments are only specific examples of the disclosure described in the section of the means for solving the problem.
[0049] Hereinafter, while embodiments for carrying out the present disclosure are described by using embodiments, it is needless to say that the present disclosure is not limited to such embodiments, and can be implemented in various forms without departing from the gist of the present disclosure.
[0050] The present disclosure is applicable to a manufacturing industry of a drive device and the like.

Claims

1. A drive device comprising: a motor; an inverter that drives the motor; a power storage device connected to the inverter via a power line; a cooling device that circulates coolant in a circulation flow path including the motor, the inverter, and the power storage device; and a control device that controls the inverter and the cooling device, wherein the control device controls the inverter such that a d-axis current that flows through the motor is smaller when a temperature of the coolant is less than a first temperature threshold value than when the temperature of the coolant is not less than the first temperature threshold value when executing temperature rise d-axis control in which the inverter is controlled such that only the d-axis current flows through the motor along with operation of the cooling device according to a request to raise a temperature of the power storage device.
2. The drive device according to claim 1, wherein the control device controls the inverter such that the d-axis current that flows through the motor is smaller when the temperature of the coolant is less than the first temperature threshold value or the temperature of the power storage device is equal to or more than a second temperature threshold value that is greater than the first temperature threshold value, than when the temperature of the coolant is not less than the first temperature threshold value and the temperature of the power storage device is less than the second temperature threshold value, when executing the temperature rise d-axis control along with the operation of the cooling device.
3. The drive device according to claim 1, wherein the control device sets a duty so as to be smaller when the temperature of the coolant is less than the first temperature threshold value than when the temperature of the coolant is not less than the first temperature threshold value, sets a d-axis current command to a product of the duty and a reference current value and sets a q-axis current command to a value 0, and controls the inverter so as to cancel out a difference between the d-axis current and a q-axis current and the d-axis current command and the q-axis current command, when executing the temperature rise d-axis control.
4. The drive device according to claim 1, wherein: the drive device is able to perform external charge in which the power storage device is charged using electric power from an external power source; and the control device executes the temperature rise d-axis control along with the operation

of the cooling device during the external charge and when the request to raise the temperature of the power storage device is made.