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HYBRID VEHICLE AND POWER DETERMINATION METHOD

Abstract

A hybrid vehicle includes: a first determination part that determines a fuel injection quantity of an engine and a motor torque generated by a motor on the basis of an opening degree of the accelerator; a second determination part that determines a correction coefficient for correcting the fuel injection quantity and the motor torque on the basis of (i) the temperature of a catalyst that purifies NOx contained in exhaust gas of the engine, by reacting the NOx with ammonia, which is contained in urea water injected into the exhaust gas, and (ii) an SOC of the battery 6 that supplies electricity to the motor; and a calculation part that calculates a corrected fuel injection quantity that is smaller than the fuel injection quantity and a corrected motor torque that is larger than the motor torque on the basis of the correction coefficient.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] The present application claims priority to Japanese Patent Application number 2024-022991, filed on Feb. 19, 2024, contents of which are incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] The present disclosure relates to a hybrid vehicle and a power determination method for determining power of a drive source included in the hybrid vehicle. In a conventional hybrid electric vehicle, a NOx purification rate of a catalyst is improved by controlling the magnitude of motor output and engine output on the basis of the temperature of the catalyst for purifying NOx contained in the exhaust gas and the load required for the hybrid electric vehicle (for example, Japanese Unexamined Patent Application Publication No, 2014-227888).

[0003] The catalyst reduces NOx emissions by adsorbing ammonia, which is contained in urea water injected into the exhaust gas, and reacting NOx contained in the exhaust gas with the ammonia to reduce NOx to nitrogen and water. The higher the temperature of the catalyst, the less the amount of ammonia that can be adsorbed by the catalyst. Therefore, when an amount of change in output when increasing the engine output is large, the temperature of the catalyst also rapidly rises with the rapid rise of the exhaust gas temperature, so that the amount of ammonia that can be adsorbed by the catalyst rapidly decreases, and thus ammonia is desorbed from the catalyst and emitted.

BRIEF SUMMARY OF THE INVENTION

[0004] The present disclosure has been made in view of these points, and its object is to suppress the emission of ammonia.

[0005] A hybrid vehicle according to a first aspect of the present disclosure including: a first determination part that determines a fuel injection quantity of an engine and a motor torque generated by a motor on the basis of an opening degree of an accelerator; a second determination part that determines a correction coefficient for correcting the fuel injection quantity and the motor torque on the basis of (i) a temperature of a catalyst that purifies NOx contained in exhaust gas of the engine, by reacting the NOx with ammonia, which is contained in urea water injected into the exhaust gas, and (ii) a charging rate of a battery that supplies electricity to the motor; and a calculation part that calculates a corrected fuel injection quantity that is smaller than the fuel injection quantity and a corrected motor torque that is larger than the motor torque on the basis of the correction coefficient.

[0006] The second determination part may increase the correction coefficient as the temperature of the catalyst decreases, and the calculation part may decrease the corrected fuel injection quantity and increase the corrected motor torque, as the correction coefficient increases.

Description

BRIEF DESCIRPTION OF THE DRAWINGS

[0007] FIG. **1** illustrates an outline of a hybrid vehicle S according to the present embodiment.

[0008] FIG. **2** shows a configuration of the vehicle S.

[0009] FIG. **3** illustrates a corrected fuel injection quantity and a corrected motor torque.

[0010] FIG. **4** is an example of a processing sequence in a power determination apparatus **20**.

[0011] FIG. **5** illustrates an operation of the vehicle S according to a first modification example.

[0012] FIG. **6** illustrates an operation of the vehicle S according to a second modification example.

[0013] FIG. **7** illustrates an operation of the vehicle S according to a third modification example.

DETAILED DESCRIPTION OF THE INVENTION

[0014] Hereinafter, the invention will be described through embodiments of the invention. The below embodiments, however, are not intended to limit the invention according to the claims, and all combinations of features described in the embodiments are not necessarily essential to the solutions of the invention.

Outline of a Hybrid Vehicle S

[0015] FIG. **1** illustrates an outline of a hybrid vehicle S (hereinafter, referred to as a “vehicle S”) according to the present embodiment. The vehicle S includes an engine and a motor as drive sources, and has a function of determining an injection quantity of fuel supplied to the engine and a torque generated by the motor. For example, the vehicle S determines a corrected fuel injection quantity obtained by correcting the injection quantity of the fuel based on an accelerator opening degree and a corrected motor torque obtained by correcting the torque of the motor on the basis of the accelerator opening degree, based on (i) a charging rate of a battery that supplies electricity to the motor and (ii) the temperature of the catalyst. Then, the vehicle S causes the engine to inject fuel with the determined corrected fuel injection quantity, and causes the motor to generate the determined corrected motor torque.

[0016] The accelerator opening degree indicates a pedal depression amount by which a driver of the vehicle S presses an accelerator pedal. In the following description, the injection quantity of fuel based on the accelerator opening degree is referred to as a “fuel injection quantity”, the torque of the motor based on the accelerator opening degree is referred to as a “motor torque”, the state of charge rate of the battery is referred to as an “SOC (State Of Charge)”, and the temperature of the catalyst is referred to as a “catalyst temperature”.

[0017] The vehicle S includes the catalyst (so-called an SCR (Selective Catalytic Reduction)) for purifying NOx contained in exhaust gas of the engine. The catalyst adsorbs ammonia, which is contained in the urea water injected into the exhaust gas, and reduces NOx contained in the exhaust gas to nitrogen and water by reacting with the ammonia, thereby purifying NOx, for example. The amount of ammonia that can be adsorbed by the catalyst decreases as the temperature of the catalyst increases.

[0018] Therefore, for example, when the road on which the vehicle S is traveling changes from a flat road to a road with an uphill slope, the engine output rapidly increases in response to the driver's operation, causing the exhaust gas temperature to rise, and as a result, the catalyst temperature also rises rapidly. This rapid rise in the catalyst temperature significantly reduces the amount of ammonia that the catalyst can absorb. As a result, when the amount of ammonia adsorbed before the catalyst temperature rises exceeds the amount of ammonia that can be adsorbed after the catalyst temperature rises, the catalyst may emit the adsorbed ammonia (causing a phenomenon known as ammonia slip). To address this issue, one possible measure is to increase the motor output instead of the engine output while traveling on an upward slope, but this measure is ineffective in situations where the SOC is reduced.

[0019] Therefore, the vehicle S determines a correction coefficient based on the catalyst temperature and the SOC. Then, on the basis of the determined correction coefficient, the vehicle S determines a corrected fuel injection quantity that is smaller than the fuel injection quantity corresponding to the accelerator opening degree and a corrected motor torque that is larger than the motor torque corresponding to the accelerator opening degree. The vehicle S determines the corrected fuel injection quantity and the corrected motor torque such that the sum of the engine output corresponding to the fuel injection quantity and the output of the motor generating the motor torque matches or approximates the sum of the engine output corresponding to the corrected fuel injection quantity and the output of the motor generating the corrected motor torque, for example.

[0020] First, the vehicle S determines the fuel injection quantity corresponding to the accelerator opening degree by referencing a fuel injection quantity map M**1** ((**1**) shown in FIG. **1**). In the fuel injection quantity map M**1**, a greater fuel injection quantity corresponds to a greater accelerator opening degree. The vehicle S determines the motor torque corresponding to the accelerator opening degree by referencing the motor torque map M**2** ((**2**) shown in FIG. **1**). In the motor torque map M**2**, a greater motor torque corresponds to a greater accelerator opening degree.

[0021] The vehicle S determines a correction coefficient corresponding to the catalyst temperature and the SOC by referencing a correction coefficient map M**3** ((**3**) shown in FIG. **1**). The correction coefficient is a coefficient for correcting the fuel injection quantity and the motor torque, and the correction coefficient map M**3** indicates the correction coefficient corresponding to the catalyst temperature and the SOC. The correction coefficient and the correction coefficient map M**3** will be described later.

[0022] By referencing a fuel injection quantity correction term value map M**4**, the vehicle S determines a fuel injection quantity correction term value corresponding to the accelerator opening degree and an engine speed ((**4**) shown in FIG. **1**). By referencing a motor torque correction term value map M**5**, the vehicle S determines a motor torque correction term value corresponding to the accelerator opening degree and the engine speed ((**5**) shown in FIG. **1**). The fuel injection quantity correction term value, the motor torque correction term value, the fuel injection quantity correction term value map M**4**, and the motor torque correction term value map M**5** will be described later.

[0023] Next, the vehicle S calculates, as a first correction amount, a multiplication value obtained by multiplying the fuel injection quantity correction term value by the correction coefficient ((**6**) shown in FIG. **1**), and determines, as the corrected fuel injection quantity, a subtraction value obtained by subtracting the first correction amount from the fuel injection quantity ((**7**) shown in FIG. **1**). The vehicle S calculates, as a second correction amount, a multiplication value obtained by multiplying the motor torque correction term value by the correction coefficient ((**8**) shown in FIG. **1**), and determines, as the corrected motor torque, an addition value obtained by adding the second correction amount to the motor torque ((**9**) shown in FIG. **1**).

[0024] By operating as described above, the vehicle S can increase the engine output in a manner that prevents the catalyst temperature from rising rapidly when the catalyst temperature is in a lowered state. As a result, the vehicle S can suppress a decrease in the SOC while also suppressing the occurrence of ammonia slip. Since the vehicle S has suppressed the decrease in the SOC, it can increase the motor output when ammonia slip is likely to occur, thereby suppressing ammonia slip. Furthermore, when the catalyst temperature and the SOC are high, the vehicle S can suppress an increase in the catalyst temperature by increasing the motor output relative to the engine output, thereby suppressing ammonia slip. Hereinafter, the configuration and operation of the vehicle S will be described in detail.

Configuration of the Vehicle S

[0025] FIG. **2** illustrates a configuration of the vehicle S. The vehicle S shown in FIG. **2** includes an accelerator device **1**, an engine **2**, a catalyst **3**, an exhaust passage **4**, a motor **5**, a battery **6**, a temperature sensor **11**, a flow rate sensor **12**, a rotation speed sensor **13**, a driving control device **14**, and a power determination apparatus **20**. FIG. **2** shows, as an example, a case where the accelerator opening degree is a pedal depression amount of an accelerator pedal.

[0026] The accelerator device **1** is a device for controlling acceleration of the vehicle S. The accelerator device **1** includes, for example, the accelerator pedal and a pedal sensor, and the pedal sensor detects the pedal depression amount indicating an amount that a driver of the vehicle S steps on the accelerator pedal. The accelerator device **1** outputs the detected pedal depression amount to the power determination apparatus **20** as the accelerator opening degree.

[0027] The engine **2** is a drive source of the vehicle S, and is an internal combustion engine that generates power by combusting and expanding a mixture of fuel and intake air (air). The catalyst **3** is a purification device for purifying the exhaust gas of the engine **2** flowing through the exhaust passage **4**, which is provided downstream of the engine **2** in the exhaust passage **4**, and includes, for example, an SCR. The catalyst **3** purifies NOx contained in the exhaust gas of the engine **2** by reacting the NOx with ammonia, which is contained in the urea water injected into the exhaust gas. The exhaust passage **4** is a passage through which the exhaust gas of the engine **2** flows to the catalyst **3**.

[0028] The motor **5** is a drive source of the vehicle S, and is an electric motor that generates power by electricity supplied from the battery **6** via an inverter (not shown). The motor **5** may cause the battery **6** to store electricity generated by operating as a generator (so-called regenerative braking) when braking the vehicle S. The battery **6** is a rechargeable storage battery and supplies electricity to the motor **5**. The battery **6** stores, for example, electricity supplied from an external source of the vehicle S, electricity generated by the motor **5**, and electricity generated by a solar panel (not shown) included on the vehicle S.

[0029] The temperature sensor **11** is a sensor that is provided upstream of the catalyst **3** in the exhaust passage **4**, detects the temperature of an inlet through which exhaust gas flows into the catalyst **3**, and outputs the detected temperature to the power determination apparatus **20**. The flow rate sensor **12** is a sensor for detecting a flow rate of exhaust gas flowing through the exhaust passage **4** (hereinafter referred to as “exhaust flow rate”) and outputting the flow rate to the power determination apparatus **20**. The rotation speed sensor **13** is a sensor for detecting the rotation speed of the engine **2** and outputting the rotation speed to the power determination apparatus **20**.

[0030] The driving control device **14** is, for example, a device including one or more processors such as central processing units (CPUs) or electronic control units (ECUs), and a storage part. The driving control device **14** causes the processor to execute programs stored in the storage part, thereby causing the engine **2** to inject fuel with the corrected fuel injection quantity determined by the power determination apparatus **20**, and causing the motor **5** to generate the corrected motor torque determined by the power determination apparatus **20**. The driving control device **14** acquires the charge rate of the battery **6** and provides notification about the charge rate to the power determination apparatus **20**.

[0031] The power determination apparatus **20** is, for example, a device including one or more processors such as the CPU or the ECU. The power determination apparatus **20** determines the corrected fuel injection quantity and the corrected motor torque on the basis of, for example, the accelerator opening degree acquired from the accelerator device **1**, the temperature acquired from the temperature sensor **11**, and the SOC acquired from the driving control device **14**. The power determination apparatus **20** provides notification about the determined corrected fuel injection quantity and corrected motor torque to the driving control device **14**, thereby causing the engine **2** to inject fuel with the corrected fuel injection quantity, and causing the motor **5** to generate the corrected motor torque. The power determination apparatus **20** may have a housing including electronic components, or may be a printed substrate on which the electronic components are mounted. The power determination apparatus **20** may include the driving control device **14**. The configuration and operation of the power determination apparatus **20** will be described in detail below.

Configuration of the Power Determination Apparatus **20**

[0032] As shown in FIG. **2**, the power determination apparatus **20** includes a storage part **21** and a control part **22**. The control part **22** includes an acquisition part **221**, an estimation part **222**, a first determination part **223**, a second determination part **224**, a third determination part **225**, and a calculation part **226**.

[0033] The storage part **21** includes, for example, a storage medium such as a read only memory (ROM), a random access memory (RAM), a hard disk drive (HDD), or a solid state drive (SSD). The storage part **21** stores programs executed by the control part **22** and various types of information for determining the corrected fuel injection quantity and the corrected motor torque. As an example, the storage part **21** stores the fuel injection quantity map M**1**, a motor torque map M**2**, a correction coefficient map M**3**, a fuel injection quantity correction term value map M**4**, and a motor torque correction term value map M**5** shown in FIG. **1**.

[0034] The control part **22** is, for example, a processor such as a CPU or an ECU. The control part **22** functions as the acquisition part **221**, the estimation part **222**, the first determination part **223**, the second determination part **224**, the third determination part **225**, and the calculation part **226** by executing the programs stored in the storage part **21**. The control part **22** may be configured by a single processor, or may be configured by a plurality of processors or a combination of one or more processors and an electronic circuit. A configuration of each part implemented by the control part **22** will be described below.

[0035] The acquisition part **221** acquires various types of information from the external source of the power determination apparatus **20** at a predetermined control cycle. The control cycle is, for example, 0.1 seconds. For example, the acquisition part **221** acquires the accelerator opening degree from the accelerator device **1**, the temperature of the inlet of the catalyst **3** from the temperature sensor **11**, the flow rate of the exhaust gas flowing through the exhaust passage **4** from the flow rate sensor **12**, the rotation speed of the engine **2** from the rotation speed sensor **13**, and the SOC of the battery **6** from the driving control device **14**. The acquisition part **221** stores, for example, various kinds of acquired information in the storage part **21**.

[0036] The estimation part **222** estimates the temperature of the catalyst **3** (catalyst temperature). The estimation part **222** estimates the catalyst temperature on the basis of, for example, the temperature of the inlet through which the exhaust gas flows into the catalyst **3** and the flow rate of the exhaust gas. For example, the estimation part **222** acquires the temperature detected by the temperature sensor **11** and the flow rate of the exhaust gas detected by the flow rate sensor **12** from the acquisition part **221**, and estimates the catalyst temperature as a result of the exhaust gas, which has the acquired temperature and flow rate, coming into contact with the catalyst **3**. The estimation part **222** may estimate the temperature detected by the temperature sensor **11** as the catalyst temperature.

[0037] The first determination part **223** determines a fuel injection quantity of the engine **2** and the motor torque generated by the motor **5** on the basis of the accelerator opening degree. For example, the first determination part **223** determines the fuel injection quantity of the engine **2** corresponding to the accelerator opening degree acquired by the acquisition part **221** by referencing the fuel injection quantity map M**1** stored in the storage part **21** ((**1**) shown in FIG. **1**). For example, the first determination part **223** determines the motor torque corresponding to the accelerator opening degree acquired by the acquisition part **221** by referencing the motor torque map M**2** stored in the storage part **21** ((**2**) shown in FIG. **1**).

[0038] The second determination part **224** determines a correction coefficient for correcting the fuel injection quantity and the motor torque on the basis of the catalyst temperature and the SOC of the battery **6**. The correction coefficient is a coefficient for calculating the first correction amount of the fuel injection quantity and the second correction amount of the motor torque, and is, for example, a coefficient indicating a value equal to or greater than 0. The second determination part **224** determines a correction coefficient corresponding to the catalyst temperature estimated by the estimation part **222** and the SOC of the battery **6** acquired by the acquisition part **221** from the driving control device **14**, for example, by referencing the correction coefficient map M**3** stored in the storage part **21** ((**3**) shown in FIG. **1**).

[0039] For example, the second determination part **224** references the correction coefficient map M**3**, which is stored in the storage part **21** and includes correction coefficients that indicate larger values as the catalyst temperature decreases. Based on this map, the second determination part **224** increases the correction coefficient as the catalyst temperature decreases. Since the second determination part **224** determines the correction coefficient in this manner, the vehicle S can reduce the corrected fuel injection quantity and increase the corrected motor torque as the catalyst temperature decreases. Therefore, even when the vehicle S rapidly increases the output of the engine **2** while the catalyst temperature is in the lowered sate, the second determination part **224** can suppress a rapid rise in exhaust gas temperature by gradually increasing the fuel injection quantity, thereby preventing the rapid increase in the catalyst temperature. Consequently, the second determination part **224** can suppress the occurrence of ammonia slip caused by the rapid rise in the catalyst temperature.

[0040] For example, the second determination part **224** increases the correction coefficient as the SOC of the battery **6** increases. That is, the correction coefficient map M**3** includes correction coefficients that indicate larger values as the SOC increases. Since the second determination part **224** determines the correction coefficient in this manner, the second determination part **224** can reduce the corrected fuel injection quantity and increase the corrected motor torque as the SOC of the battery **6** increases. As a result, when the SOC of the battery **6** is high, the second determination part **224** can suppress an increase in the catalyst temperature by reducing the output of the engine **2**, thereby suppressing the occurrence of ammonia slip.

[0041] The third determination part **225** determines (i) a fuel injection quantity correction term value for correcting the fuel injection quantity and (ii) a motor torque correction term value for correcting the motor torque, on the basis of the rotation speed of the engine **2** and the accelerator opening degree. The fuel injection quantity correction term value is a term for calculating the first correction amount of the fuel injection quantity, and the motor torque correction term value is a term for calculating the second correction amount of the motor torque.

[0042] The third determination part **225** references, for example, the fuel injection quantity correction term value map M**4** stored in the storage part **21** to determine a fuel injection quantity correction term value corresponding to the engine speed and the accelerator opening degree of the engine **2**, acquired by the acquisition part **221** ((**4**) shown in FIG. **1**). The fuel injection quantity correction term value map M**4** includes a fuel injection quantity correction term value corresponding to the rotation speed of the engine **2** and the accelerator opening degree, and indicates a fuel injection quantity correction term value for increasing the first correction amount as the rotation speed of the engine **2** and the accelerator opening degree increase. For example, by referencing the fuel injection quantity correction term value map M**4**, the third determination part **225** determines a fuel injection quantity correction term value for determining a greater first correction amount as the rotation speed of the engine **2** and the accelerator opening degree increase.

[0043] The third determination part **225** references, for example, the motor torque correction term value map M**5** stored in the storage part **21** to determine a motor torque correction term value corresponding to the rotation speed of the engine **2** and the accelerator opening degree acquired by the acquisition part **221** ((**5**) shown in FIG. **1**). The motor torque correction term value map M**5** includes a motor torque correction term value corresponding to the rotation speed of the engine **2** and the accelerator opening degree. The motor torque correction term value map M**5** indicates a motor torque correction term value for increasing the second correction amount as the rotation speed of the engine **2** and the accelerator opening degree increase. For example, by referencing the motor torque correction term value map M**5**, the third determination part **225** determines a motor torque correction term value for determining a greater second correction amount as the rotation speed of the engine **2** and the accelerator opening degree increase.

[0044] The magnitude of the rotation speed of the engine **2** corresponds to the exhaust flow rate at the current time, while the magnitude of the accelerator opening degree corresponds to the exhaust flow rate after a predetermined time has passed from the current time. The higher the exhaust gas flow rate, the higher the catalyst temperature. Accordingly, it can be said that the fuel injection quantity correction term value map M**4** includes the fuel injection quantity correction term value that corresponds to both the amount of change in the catalyst temperature after the predetermined time from the current time and the catalyst temperature at the current time, and the motor torque correction term value map M**5** includes the motor torque correction term value that corresponds to the amount of change in the catalyst temperature after the predetermined time from the current time and the catalyst temperature at the current time. Therefore, by referencing the fuel injection quantity correction term value maps M**4** and M**5**, the third determination part **225** can determine the fuel injection quantity correction term value and the motor torque correction term value that correspond to the amount of change in the catalyst temperature after the predetermined time from the current time and the catalyst temperature at the current time.

[0045] The calculation part **226** calculates a corrected fuel injection quantity that is smaller than the fuel injection quantity and a corrected motor torque that is larger than the motor torque, on the basis of the correction coefficient determined by the second determination part **224**. For example, the calculation part **226** decreases the corrected fuel injection quantity and increases the corrected motor torque as the correction coefficient increases.

[0046] FIG. **3** is a diagram for explaining the corrected fuel injection quantity and the corrected motor torque. The horizontal axis of FIG. **3** represents time, and the vertical axis of FIG. **3** represents the "catalyst temperature" of the catalyst **3**, the "SOC" of the battery **6**, the "correction coefficient" determined by the second determination part **224**, the "injection quantity", and the "torque". In the "injection quantity" shown in FIG. **3**, a solid line indicates the corrected fuel injection quantity ((**7**) shown in FIG. **1**), and a dashed line indicates the fuel injection quantity ((**1**) shown in FIG. **1**). In the "torque" shown in FIG. **3**, a solid line indicates the corrected motor torque ((**9**) shown in FIG. **1**), and a dashed line indicates the motor torque ((**2**) shown in FIG. **1**). The time periods (a time period P**0** and a time period P**1**) before a time T**2** shown in FIG. **3** are when the vehicle S travels on a flat road, and a time period P**2** after the time T**2** is when the vehicle S travels on the road with an uphill slope. In the time period P**1** shown in FIG. **3**, the SOC increases due to deceleration or stopping of the vehicle S, or power generation by a solar panel included on the vehicle S.

[0047] As illustrated in FIG. **3**, during the time periods P**0** and P**1**, the second determination part **224** increases the correction coefficient from a coefficient H**0** to a coefficient H**2** because the catalyst temperature decreases from a temperature C**0** to a temperature C**1**, and the SOC increases from a state of charge B**0** to a state of charge B**2**. Then, for example, at the time T**2**, the calculation part **226** calculates a corrected fuel injection quantity E**21**, which is smaller than a fuel injection quantity E**22** determined by the first determination part **223**, and calculates a corrected motor torque M**21**, which is larger than a motor torque M**22** determined by the first determination part **223**.

[0048] Next, during the time period P**2**, the second determination part **224** decreases the correction coefficient from the coefficient H**2** to a coefficient H**3** because the catalyst temperature increases from the temperature C**1** to a temperature C**3**, and the SOC decreases from state of charge B**2** to the state of charge B**0**. Then, for example, at a time T**3**, the calculation part **226** calculates a corrected fuel injection quantity E**31**, which is smaller than a fuel injection quantity E**32** determined by the first determination part **223**, and a corrected motor torque M**31**, which is larger than a motor torque M**32** determined by the first determination part **223**.

[0049] During the time periods P**0**, P**1**, and P**2** shown in FIG. **3**, a difference "E**22**-E**21**" between the fuel injection quantity and the corrected fuel injection quantity at the time T**2**, where the correction coefficient is at its maximum, is larger than a difference between the fuel injection quantity and the corrected fuel injection quantity at other times. That is, the calculation part **226** calculates the corrected fuel injection quantity, which decreases relative to the fuel injection quantity as the correction coefficient increases. A difference "M**21**-M**22**" between the corrected motor torque and the motor torque at the time T**2** is also larger than a difference between the corrected motor torque and the motor torque at other times. That is, the calculation part **226** calculates the corrected motor torque, which increases relative to the motor torque as the correction coefficient increases.

[0050] Since the calculation part **226** operates as described above, it can reduce the corrected fuel injection quantity and increase the corrected motor torque when the correction coefficient increases due to a decrease in the catalyst temperature (e.g., the time period P**0** shown in FIG. **3**). Therefore, when the catalyst temperature is in the lowered state, the calculation part **226** can make the output of the engine **2** smaller than the output of the motor **5**. As a result, by increasing the motor output, the calculation part **226** can reduce the likelihood of ammonia slip, which is likely to occur due to a sudden increase in the fuel injection quantity.

[0051] Furthermore, when the correction coefficient is large due to a high SOC, the calculation part **226** can reduce the corrected fuel injection quantity and increase the corrected motor torque (e.g., the time period P**1** shown in FIG. **3**). Therefore, the calculation part **226** can drive the vehicle S by increasing the output of the motor **5** because the SOC is high, even when, for example, a large output is required to travel on a road with an uphill slope during the time period P**2**. Thus, the output of the engine **2** can be suppressed. As a result, the calculation part **226** can suppress an increase in the catalyst temperature, thereby suppressing ammonia slip.

[0052] The calculation part **226** calculates, for example, a corrected fuel injection quantity ((**7**) shown in FIG. **1**) obtained by subtracting, from the fuel injection quantity, the first correction amount ((**6**) shown in FIG. **1**) obtained by multiplying the fuel injection quantity correction term value by the correction coefficient. For example, the calculation part **226** calculates the first correction amount by multiplying the fuel injection quantity correction term value by the correction coefficient after substituting the correction coefficient, which is determined by the second determination part **224**, into the coefficient included in the fuel injection quantity correction term value. The calculation part **226** then calculates the corrected fuel injection quantity by subtracting the first correction amount from the fuel injection quantity.

[0053] For example, the calculation part **226** calculates the corrected motor torque ((**9**) shown in FIG. **1**) obtained by adding, to the motor torque, the second correction amount ((**8**) shown in FIG. **1**) obtained by multiplying the motor torque correction term value by the correction coefficient. For example, the calculation part **226** calculates the second correction amount by multiplying the motor torque correction term value by the correction coefficient after substituting the correction coefficient, which is determined by the second determination part **224**, into the coefficient included in the motor torque correction term value. The calculation part **226** then calculates the corrected motor torque by adding the second correction amount to the motor torque.

[0054] Since the calculation part **226** operates as described above, the calculation part **226** can use the fuel injection quantity correction term value and the motor torque correction term value that correspond to (i) the rotation speed of the engine **2** corresponding to the catalyst temperature at the current time and (ii) the accelerator opening degree corresponding to the catalyst temperature after the predetermined time from the current time. As a result, the calculation part **226** can calculate the corrected fuel injection quantity and the corrected motor torque corresponding to the catalyst temperature at the current time and the amount of change in the catalyst temperature after the predetermined time from the current time, thereby improving the accuracy of suppressing ammonia slip.

[0055] The calculation part **226** outputs the calculated corrected fuel injection quantity and the corrected motor torque to the driving control device **14**, thereby causing the engine **2** to inject fuel at the corrected fuel injection quantity and causing the motor **5** to generate the corrected motor torque.

Processing Sequence in the Power Determination Apparatus **20**

[0056] FIG. **4** is a diagram illustrating an example of a processing sequence in the power determination apparatus **20**. The processing sequence shown in FIG. **4** shows an operation of calculating the corrected fuel injection quantity and the corrected motor torque by the power determination apparatus **20** executing the operations shown in FIG. **1**. The power determination apparatus **20** executes the processing sequence shown in FIG. **4** at a predetermined control cycle.

[0057] The acquisition part **221** acquires an accelerator opening degree from the accelerator device **1** and acquires an engine speed from the rotation speed sensor **13** (S**11**). The first determination part **223** determines a fuel injection quantity ((**1**) shown in FIG. **1**) corresponding to the accelerator opening degree acquired by the acquisition part **221** and the motor torque ((**2**) shown in FIG. **1**) corresponding to the accelerator opening degree (S**12**).

[0058] The acquisition part **221** acquires the temperature of the catalyst **3** from the temperature sensor **11**, and acquires the SOC of the battery **6** from the driving control device **14** (S**13**). The second determination part **224** determines a correction coefficient ((**3**) shown in FIG. **1**) on the basis of (i) the SOC acquired by the acquisition part **221** and (ii) the catalyst temperature estimated by the estimation part **222** on the basis of the temperature of the catalyst **3** acquired by the acquisition part **221** (S**14**). The third determination part **225** determines a fuel injection quantity correction term value ((**4**) shown in FIG. **1**) and a motor torque correction term value ((**5**) shown in FIG. **1**) on the basis of the accelerator opening degree and the engine speed acquired by the acquisition part **221** (S**15**).

[0059] The calculation part **226** calculates a first correction amount ((**6**) shown in FIG. **1**) by substituting the correction coefficient determined by the second determination part **224** into the coefficient included in the fuel injection quantity correction term value determined by the third determination part **225** (S**16**). For example, the calculation part **226** determines, as the first correction amount, a multiplication value obtained by multiplying the fuel injection quantity correction term value by the correction coefficient. The calculation part **226** calculates a second correction amount ((**8**) shown in FIG. **1**) by substituting the correction coefficient into the coefficient included in the motor torque correction term value determined by the third determination part **225** (S**16**). For example, the calculation part **226** determines, as the second correction amount, a multiplication value obtained by multiplying the motor torque correction term value by the correction coefficient. The calculation part **226** calculates a corrected fuel injection quantity ((**7**) shown in FIG. **1**) obtained by subtracting the first correction amount from the fuel injection quantity and a corrected motor torque ((**9**) shown in FIG. **1**) obtained by adding the second correction amount to the motor torque (S**17**), and ends the process.

First Modification Example

[0060] In the above description, the calculation part **226** calculates the first correction amount obtained by multiplying the fuel injection quantity correction term value by the correction coefficient, and the second correction amount obtained by multiplying the motor torque correction term value by the correction coefficient, but the present disclosure is not limited thereto. The calculation part **226** may calculate the first correction amount and the second correction amount without relying on the fuel injection quantity correction term value and the motor torque correction term value. FIG. **5** is a diagram illustrating an operation of the vehicle S according to a first modification example. The vehicle S shown in FIG. **5** differs from the vehicle S shown in FIG. **1** in two ways: (i) it does not include the fuel injection quantity correction term value map M**4** and the motor torque correction term value map M**5**, and (ii) it includes (**4**) and (**6**) shown in FIG. **5**. In all other respects, the two vehicles are the same.

[0061] The calculation part **226** calculates, for example, a corrected fuel injection quantity ((**5**) shown in FIG. **5**) obtained by subtracting, from the fuel injection quantity, a first correction amount ((**4**) shown in FIG. **5**) obtained by multiplying the fuel injection quantity by the correction coefficient. The calculation part **226** calculates, for example, a corrected motor torque ((**7**) shown in FIG. **5**) obtained by adding, to the motor torque, a second correction amount ((**6**) shown in FIG. **5**) obtained by multiplying the motor torque by a correction coefficient. Since the calculation part **226** operates in this manner, the vehicle S can reduce the computation load required to calculate the corrected fuel injection quantity and the corrected motor torque.

Second Modification Example

[0062] In the above description, the operation where the second determination part **224** determines a single correction coefficient for calculating the corrected fuel injection quantity and the corrected motor torque is exemplified, but the present disclosure is not limited thereto. The second determination part **224** may determine two correction coefficients. Specifically, the second determination part **224** may determine a first correction coefficient for correcting the fuel injection quantity and a second correction coefficient for correcting the motor torque.

[0063] FIG. **6** is a diagram illustrating an operation of the vehicle S according to a second modification example. The vehicle S shown in FIG. **6** differs from the vehicle S shown in FIG. **5** in two ways: (i) it includes a first correction coefficient map M**3***a* and a second correction coefficient map M**3***b*, and (ii) it includes (**3***a*) and (**3***b*) shown in FIG.

[0064] **6**. In all other respects, the two vehicles are the same. Similarly to the correction coefficient map M**3** shown in FIG. **5**, the first correction coefficient map M**3***a* and the second correction coefficient map M**3***b* shown in FIG. **6** are maps that include correction coefficients corresponding to the SOC of the battery **6** and the catalyst temperature, and include correction coefficients that indicate larger values as the catalyst temperature decreases and the SOC increases.

[0065] The second determination part **224** determines a first correction coefficient corresponding to the catalyst temperature and the SOC, for example, by referencing the first correction coefficient map M**3***a* stored in the storage part **21** ((**3***a*) shown in FIG. **6**). The second determination part **224** determines a second correction coefficient corresponding to the catalyst temperature and the SOC, for example, by referencing the second correction coefficient map M**3***b* stored in the storage part **21** ((**3***b*) shown in FIG. **6**).

[0066] The calculation part **226** calculates a corrected fuel injection quantity on the basis of the first correction coefficient, and calculates a corrected motor torque on the basis of the second correction coefficient. For example, the calculation part **226** calculates a first correction amount by multiplying the fuel injection quantity by the first correction coefficient ((**4**) shown in FIG. **6**), and calculates the corrected fuel injection quantity by subtracting the first correction amount from the fuel injection quantity ((**5**) shown in FIG. **6**). For example, the calculation part **226** calculates a second correction amount by multiplying the motor torque by the second correction coefficient ((**6**) shown in FIG. **6**), and calculates the corrected motor torque by adding the second correction amount to the motor torque ((**7**) shown in FIG. **6**).

[0067] Since the second determination part **224** determines the correction coefficients as described above, the calculation part **226** can multiply the fuel injection quantity and the motor torque respectively by different correction coefficients. As a result, the calculation part **226** can easily adjust the first correction amount for the corrected fuel injection quantity and the second correction amount for the corrected motor torque.

Third Modification Example

[0068] In the above description, the calculation part **226** calculates the corrected fuel injection quantity obtained by subtracting the first correction amount from the fuel injection quantity and the corrected motor torque obtained by adding the second correction amount to the motor torque, but the present disclosure is not limited to this. The calculation part **226** may calculate a corrected fuel injection quantity obtained by multiplying the fuel injection quantity by a first correction coefficient and a corrected motor torque obtained by multiplying the motor torque by a second correction coefficient.

[0069] FIG. **7** is a diagram illustrating an operation of the vehicle S according to a third modification example. The vehicle S shown in FIG. **7** differs from the vehicle S shown in FIG. **6** in that it includes (**4**) and (**5**) shown in FIG. **7**, and is the same in other respects. In FIG. **7**, the second determination part **224** determines the first correction coefficient ((**3***a*) shown in FIG. **7**) indicating a value greater than or equal to 0 and less than or equal to 1, and determines the second correction coefficient ((**3***b*) shown in FIG. **7**) indicating a value greater than or equal to **1**, for example.

[0070] The calculation part **226** determines a multiplication value obtained by multiplying the fuel injection quantity by the first correction coefficient as the corrected fuel injection quantity ((**4**) shown in FIG. **7**), and determines a multiplication value obtained by multiplying the motor torque by the second correction coefficient as the corrected motor torque ((**5**) shown in FIG. **7**). Since the second determination part **224** and the calculation part **226** operate as described above, the vehicle S can reduce the computation load required to calculate the corrected fuel injection quantity and the corrected motor torque.

Fourth Modification Example

[0071] In the above description, the operation where the second determination part **224** determines the correction coefficient indicating a value equal to or greater than 0 has been exemplified, but the present disclosure is not limited thereto. The second determination part **224** may determine a correction coefficient indicating a value less than 0. In this case, the calculation part **226** calculates, for example, a corrected fuel injection quantity obtained by adding the first correction amount to the fuel injection quantity and a corrected motor torque obtained by subtracting the second correction amount from the motor torque.

Effects of the Vehicle S

[0072] As described above, the vehicle S includes the first determination part **223** that determines the fuel injection quantity of the engine **2** and the motor torque generated by the motor **5** on the basis of the opening degree of the accelerator, the second determination part **224** that determines the correction coefficient for correcting the fuel injection quantity and the motor torque on the basis of (i) the temperature of the catalyst **3** that purifies NOx contained in the exhaust gas of the engine **2**, by reacting the NOx with ammonia, which is contained in the urea water injected into the exhaust gas, and (ii) the SOC of the battery **6** that supplies electricity to the motor **5**, and the calculation part **226** that calculates the corrected fuel injection quantity that is smaller than the fuel injection quantity and the corrected motor torque that is larger than the motor torque.

[0073] With the vehicle S configured in this manner, it can suppress a rapid increase in the output of the engine **2** when the catalyst temperature is in a lowered state, thereby preventing a rapid rise in the catalyst temperature. As a result, the vehicle S can prevent the amount of ammonia that can be adsorbed by the catalyst **3** from rapidly decreasing due to the rapid rise in the catalyst temperature, and suppress emissions of ammonia desorbed from the catalyst **3**. Furthermore, when the SOC of the battery **6** is high, the vehicle S can increase the motor output relative to the engine output, and thus can suppress emissions of ammonia desorbed from the catalyst **3**.

[0074] The present disclosure is explained on the basis of the exemplary embodiments. The technical scope of the present disclosure is not limited to the scope explained in the above embodiments and it is possible to make various changes and modifications within the scope of the disclosure. For example, all or part of the apparatus can be configured with any unit which is functionally or physically dispersed or integrated. Further, new exemplary embodiments generated by arbitrary combinations of them are included in the exemplary embodiments. Further, effects of the new exemplary embodiments brought by the combinations also have the effects of the original exemplary embodiments.

Claims

1. A hybrid vehicle comprising: a first determination part that determines a fuel injection quantity of an engine and a motor torque generated by a motor on the basis of an opening degree of an accelerator; a second determination part that determines a correction coefficient for correcting the fuel injection quantity and the motor torque on the basis of (i) a temperature of a catalyst that purifies NOx contained in exhaust gas of the engine, by reacting the NOx with ammonia, which is contained in urea water injected into the exhaust gas, and (ii) a charging rate of a battery that supplies electricity to the motor; and a calculation part that calculates a corrected fuel injection quantity that is smaller than the fuel injection quantity and a corrected motor torque that is larger than the motor torque on the basis of the correction coefficient.

2. The hybrid vehicle according to claim 1, wherein the second determination part increases the correction coefficient as the temperature of the catalyst decreases, and the calculation part decreases the corrected fuel injection quantity and increases the corrected motor torque, as the correction coefficient increases.

3. The hybrid vehicle according to claim 2, wherein the second determination part increases the correction coefficient as a state of charge of the battery increases.

4. The hybrid vehicle according to claim 1, wherein the second determination part determines, as the correction coefficient, a first correction coefficient for correcting the fuel injection quantity and a second correction coefficient for correcting the motor torque, and the calculation part calculates the corrected fuel injection quantity on the basis of the first correction coefficient, and calculates the corrected motor torque on the basis of the second correction coefficient.

5. The hybrid vehicle according to claim 4, wherein the second determination part determines the first correction coefficient indicating a value greater than or equal to 0 and less than or equal to 1, and determines the second correction coefficient indicating a value greater than or equal to 1.

6. The hybrid vehicle according to claim 1, wherein the calculation part calculates the corrected fuel injection quantity obtained by subtracting, from the fuel injection quantity, a first correction amount obtained by multiplying the fuel injection quantity by the correction coefficient, and the corrected motor torque obtained by adding, to the motor torque, a second correction amount obtained by multiplying the motor torque by the correction coefficient.

7. The hybrid vehicle according to claim 1, further comprising: a third determination part that determines a fuel injection quantity correction term value for correcting the fuel injection quantity and a motor torque correction term value for correcting the motor torque, on the basis of an opening degree of the accelerator and a rotation speed of the engine, the calculation part calculates the corrected fuel injection quantity obtained by subtracting, from the fuel injection quantity, a first correction amount obtained by multiplying the fuel injection quantity correction term value by the correction coefficient, and the corrected motor torque obtained by adding, to the motor torque, a second correction amount obtained by multiplying the motor torque correction term value by the correction coefficient.

8. The hybrid vehicle according to claim 7, wherein the third determination part determines the fuel injection quantity correction term value for determining a greater first correction amount as the rotation speed of the engine and the opening degree of the accelerator increase.

9. The hybrid vehicle according to claim 7, wherein the third determination part determines the motor torque correction term value for determining a greater second correction amount as the rotation speed of the engine and the opening degree of the accelerator increase.

10. The hybrid vehicle according to claim 1, further comprising: an estimation part that estimates the temperature of the catalyst on the basis of a temperature of an inlet through which the exhaust gas flows into the catalyst and a flow rate of the exhaust gas.

11. A power determination method comprising: a first determination step of determining a fuel injection quantity of an engine and a motor torque generated by a motor on the basis of an opening degree of an accelerator; a second determination step of determining a correction coefficient for correcting the fuel injection quantity and the motor torque on the basis of (i) a temperature of a catalyst that purifies NOx contained in exhaust gas of the engine, by reacting the NOx with ammonia, which is contained in urea water injected into the exhaust gas, and (ii) a charging rate of a battery that supplies electricity to the motor; and a calculation step of calculating a corrected fuel injection quantity that is smaller than the fuel injection quantity and a corrected motor torque that is larger than the motor torque on the basis of the correction coefficient.