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HYBRID VEHICLE

Abstract

A hybrid vehicle includes an engine and a motor as drive sources, and including a detection part that detects a start timing at which the hybrid vehicle passes through a start position of an uphill slope, and an output control part that increases an output of the engine and decreases an output of the motor as the time elasped from the start timing increases.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority to Japanese Patent Application number 2024-022816, 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. 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 catalyst has the characteristic that the amount of ammonia it can adsorb decreases as the temperature increases. Therefore, when the engine output rapidly increases due to a change in the gradient of the road during travel, the temperature of the catalyst also rises sharply along with the rapid rise in the exhaust gas temperature, causing ammonia to be 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 an aspect of the present disclosure includes an engine and a motor as drive sources, the hybrid vehicle including: a detection part that detects a start timing at which the hybrid vehicle passes through a start position of an uphill slope; and an output control part that increases an output of the engine and decreases an output of the motor as a time elapsed from the start timing increases.

Description

BRIEF DESCIRPTION OF THE DRAWINGS

[0006] FIG. **1** illustrates an outline of a hybrid vehicle S according to the present embodiment.

[0007] FIG. **2** illustrates an output of an engine **6** and an output of a motor **4**.

[0008] FIG. **3** shows changes in engine output and motor output in a time period PO.

[0009] FIG. **4** shows an example of a processing sequence in a power determination apparatus **20**.

[0010] FIG. **5** shows an operation of correcting a ratio of the outputs of the engine **6** and the motor **4**.

DETAILED DESCRIPTION OF THE INVENTION

[0011] 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

[0012] 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 shown in FIG. **1** includes a receiving device **1**, an accelerator device **2**, a vehicle speed sensor **3**, a motor **4**, a battery **5**, an engine **6**, an exhaust passage **7**, an injection device **8**, a catalyst **9**, a driving control device **10**, and a power determination apparatus **20**. The vehicle S has a function of determining the output of the motor **4** and the engine **6** that are provided as drive sources, causes the motor **4** to generate torque corresponding to the determined output of the motor **4**, and causes the engine **6** to inject fuel into the engine **6** at a fuel injection quantity corresponding to the determined output of the engine **6**.

[0013] The receiving device **1** identifies the position and travel route of the vehicle S on the basis of information included in radio waves received from a Global Navigation Satellite System (GNSS) and map information stored in the receiving device **1**, and is, for example, a car navigation system. For example, the receiving device **1** identifies the position and travel route of the vehicle S, as well as the start position, distance, and angle of an uphill slope in the travel route, at a predetermined control cycle, and outputs them to the power determination apparatus **20**. The control cycle is, for example, 0.1 seconds.

[0014] The accelerator device **2** is a device for controlling acceleration of the vehicle S. The accelerator device **2** includes, for example, an accelerator pedal and a pedal sensor. The pedal sensor detects a pedal depression amount that indicates an amount that a driver of the vehicle S steps on the accelerator pedal. The accelerator device **2** outputs the detected pedal depression amount as an accelerator opening degree to the power determination apparatus **20**. The vehicle speed sensor **3** detects a vehicle speed of the vehicle S and outputs the vehicle speed to the power determination apparatus **20**.

[0015] The motor **4** is the drive source of the vehicle S, and is an electric motor that generates power by electricity supplied from the battery **5** via an inverter (not shown). When braking the vehicle S, the motor **4** may cause the battery **5** to store electricity generated by operating as a generator (so-called regenerative braking). The battery **5** is a power storage device that supplies electricity to the motor **4**, and includes a rechargeable storage battery. The battery **5** stores, for example, electricity supplied from external source of the vehicle S, electricity generated by the motor **4**, and electricity generated by a solar panel (not shown) included in the vehicle S.

[0016] The engine **6** is the drive source of the vehicle S, and is an internal combustion engine that generates power by combustion and expansion of a mixture of fuel and intake air (air). The exhaust passage **7** is a passage through which exhaust gas from the engine **6** flows to the catalyst **9**. The injection device **8** is provided downstream of the engine **6** and upstream of the catalyst **9** in the exhaust passage **7**, injects urea water into the exhaust gas flowing through the exhaust passage **7**, and includes a urea water injector that injects the urea water.

[0017] The catalyst **9** is a device that is provided downstream of the engine **6** and the injection device **8** in the exhaust passage **7** and purifies the exhaust gas flowing through the exhaust passage **7**, and includes, for example, a Selective Catalytic Reduction (SCR). The catalyst **9** purifies NOx by, for example, adsorbing ammonia, which is contained in the urea water injected by the injection device **8**, and reacting NOx contained in the exhaust gas flowing through the exhaust passage **7** with the ammonia to generate water and nitrogen.

[0018] The driving control device **10** is, for example, a device including a processor such as a Central Processing Unit (CPU) or an Electronic Control Unit (ECU) and a storage part, and executes various processes by having the processor execute programs stored in the storage part. For example, the driving control device **10** causes the engine **6** to inject fuel with a fuel injection quantity corresponding to the engine output determined by the power determination apparatus **20** and causes the motor **4** to generate a motor torque corresponding to the motor output determined by the power determination apparatus **20**. For example, the driving control device **10** acquires a state of charge (SOC) of the battery **5** and provides notification about the state of charge to the power determination apparatus **20**.

[0019] The power determination apparatus **20** is, for example, a device including a processor such as the CPU or the ECU. The power determination apparatus **20** executes processes such as (i) determining the output of the motor **4** and the output of the engine **6** on the basis of, for example, the accelerator opening degree acquired from the accelerator device **2** and the vehicle speed acquired from the vehicle speed sensor **3**, and (ii) providing notification about each determined output to the driving control device **10**. 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 **10**.

[0020] The maximum amount of ammonia that can be adsorbed by the catalyst **9** decreases as the temperature of the catalyst **9** increases. 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 output of the engine **6** rapidly increases. This causes the catalyst temperature to rise rapidly along with the rapid rise in the exhaust gas temperature, resulting in a rapid decrease in the maximum amount of ammonia that can be adsorbed by the catalyst **9**. As a result, in the catalyst **9**, because the amount of ammonia adsorbed before the catalyst temperature rises exceeds the maximum amount of ammonia that can be adsorbed after the catalyst temperature rises, ammonia may desorb from the catalyst **9**, resulting in a phenomenon known as ammonia slip.

[0021] Therefore, in traveling after passing the start position of the uphill slope, the power determination apparatus **20** increases the output of the engine **6** and decreases the output of the motor **4** as an elapsed time from the timing at which the start position was passed increases. For example, the power determination apparatus **20** gradually increases a ratio of the output of the engine **6** and gradually decreases a ratio of the output of the motor **4** among the outputs based on the accelerator opening degree and the vehicle speed, as the elapsed time increases. By operating in this manner, the power determination apparatus **20** can suppress a rapid rise in the temperature of the catalyst **9** due to a rapid increase in the output of the engine **6** during traveling on the road with the uphill slope, thereby suppressing the occurrence of ammonia slip. Hereinafter, the configuration and operation of the power determination apparatus **20** will be described in detail.

Configuration of the Power Determination Apparatus **20**

[0022] As shown in FIG. **1**, the power determination apparatus **20** includes a storage part **21** and a control part **22**. The control part **22** includes an acquisition part **221**, a determination part **222**, a detection part **223**, and an output control part **224**.

[0023] 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 output of the motor **4** and the output of the engine **6**. As an example, the storage part **21** stores a first output map that indicates the output of the motor **4** and the output of the engine **6** corresponding to the accelerator opening degree and the vehicle speed, and a second output map that indicates the output of the vehicle S corresponding to the accelerator opening degree. In the first output map, a greater output corresponds to a greater accelerator opening degree, and a greater output corresponds to a greater vehicle speed. In the second output map, a greater output corresponds to a greater accelerator opening degree.

[0024] 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 determination part **222**, the detection part **223**, and the output control part **224** by executing the programs stored in the storage part **21**. The control part **22** may be configured with a single processor, or may be configured with a plurality of processors or a combination of one or more processors and an electronic circuit. The configuration of each unit implemented by the control part **22** will be described below.

[0025] The acquisition part **221** acquires various types of information from an external source of the power determination apparatus **20** at a predetermined control cycle. For example, the acquisition part **221** acquires, from the receiving device **1**, information including the position of the vehicle S, the travel route of the vehicle S, as well as the start position, distance, and angle of the uphill slope in the travel route. For example, the acquisition part **221** acquires the depression amount of the accelerator pedal as the accelerator opening degree from the accelerator device **2**. For example, the acquisition part **221** acquires the SOC of the battery **5** from the driving control device **10**. The acquisition part **221** acquires, for example, the vehicle speed of the vehicle S from the vehicle speed sensor **3**. The acquisition part **221** stores the acquired various types of information in the storage part **21**.

[0026] The determination part **222** determines whether the vehicle S will travel on an uphill slope at a time after the current time. For example, the determination part **222** determines whether an uphill slope exists ahead in the vehicle S's traveling direction on the basis of the position of the vehicle S, the traveling route of the vehicle S, and the start position of the uphill slope in the traveling route, which are acquired by the acquisition part **221**. When determining that the uphill slope exists, the determination part **222** determines that the vehicle S will travel on the uphill slope when no branch point of the road exists between the position of the vehicle S and the start position of the uphill slope at a time prior to the timing at which the vehicle S passes through the start position of the uphill slope. The branch point refers to, for example, an intersection or a branch road on an ordinary road, a branch road leading to a junction on a highway, or a branch road leading to a parking space on a highway.
[0027] For example, when determining that the uphill slope exists and the branch point of the road exists between the position of the vehicle S and the start position of the uphill slope, the determination part **222** determines that there is a possibility that the vehicle S will not travel on an uphill slope. For example, when determining that no uphill slope exists, the determination part **222** determines that the vehicle S will not travel on an uphill slope. By operating as described above, the determination part **222** enables the output control part **224** to determine the outputs of the motor **4** and the engine **6** on the basis of whether the vehicle S will travel on the uphill slope at a time after the time before the vehicle S passes through the start position of the uphill slope.
[0028] The detection part **223** detects a start timing at which the vehicle S passes through the start position of the uphill slope. For example, the detection part **223** detects, as the start timing, a timing at which a subtraction value, obtained by subtracting a second accelerator opening degree at a time prior to the current time by the predetermined control cycle from a first accelerator opening degree at the current time, is equal to or greater than a predetermined value. The predetermined value is a value determined through experiment or simulation and is stored in the storage part **21**. The detection part **223** may also detect, as the start timing, a timing at which the start position of the gradient changes from being ahead of the traveling direction of the position of the vehicle S to being behind the traveling direction of the position of the vehicle S in the traveling route of the vehicle S.
[0029] The detection part **223** may detect an end timing at which the vehicle S has passed through an end position of the uphill slope. For example, the detection part **223** detects, as the end timing, a timing at which a subtraction value, obtained by subtracting the first accelerator opening degree at the current time from the second accelerator opening degree at a time prior to the current time by the predetermined control cycle, is equal to or greater than a predetermined value. The detection part **223** may also detect, as the end timing, a timing at which the end position of the gradient changes from being ahead of the traveling direction of the position of the vehicle S to being behind the traveling direction of the position of the vehicle S on the traveling route of the vehicle S.
[0030] The output control part **224** determines the output of the motor **4** and the output of the engine **6**, and provides notification about each determined output to the driving control device **10**. By having the output control part **224** provide notification about each output in this manner, the driving control device **10** causes the motor **4** to generate motor torque corresponding to the notified output of the motor **4** and causes the engine **6** to inject fuel at a fuel injection quantity corresponding to the notified output of the engine **6**.
[0031] When the determination part **222** determines that the vehicle S will not travel on an uphill slope, the output control part **224** identifies an output (hereinafter, referred to as a “required output”) corresponding to the driving force required of the vehicle S, on the basis of the accelerator opening degree and the vehicle speed acquired by the acquisition part **221**. The output control part **224** identifies the required output corresponding to the accelerator opening degree and the vehicle speed by referencing the storage part **21**, for example. Then, for example, the output control part **224** determines the output to be generated by the motor **4** and the output to be generated by the

engine **6** from among the identified required outputs by referencing a power distribution map N**1**, which indicates the ratio between the output of the motor **4** and the output of the engine **6** in the required output and is stored in the storage part **21**. The power distribution map N**1** will be described later.

[0032] When the determination part **222** determines that the vehicle S will travel on the uphill slope, the output control part **224** increases the output of the engine **6** and decreases the output of the motor **4** at a time after the start timing detected by the detection part **223** as the time elapsed from the start timing increase. As an example, the output control part **224** includes a timer that counts the time elapsed from the point at which the detection part **223** detected the start timing, and increases the output of the engine **6** and decreases the output of the motor **4** according to the magnitude of a count value indicated by the timer. Details regarding the operation of the output control part **224** during the period from the timing determined by the determination part **222** to the start timing, when it determines that the vehicle S will travel on the uphill slope, will be described later.

[0033] FIG. **2** illustrates the output of the engine **6** and the output of the motor **4**. The horizontal axis in FIG. **2** represents time, and the vertical axis in FIG. **2** represents the "elevation" of the road on which the vehicle S is traveling, the "SOC" of the battery **5**, the "motor output" generated by the motor **4**, the "engine output" generated by the engine **6**, and the "catalyst temperature" of the catalyst **9**. A time T**0** shown in FIG. **2** is a time indicating a determination timing at which the determination part **222** determines that the vehicle S will travel on the uphill slope, and a time T**1** is a time indicating the start timing at which the vehicle S has passed through the start position of the uphill slope. In the following description, the determination timing is referred to as "Time T**0**," and the start timing is referred to as "time T**1**". In "SOC," "motor output," "engine output," and "catalyst temperature" in FIG. **2**, a solid line indicates the operation of the vehicle S according to the present embodiment, and a dashed line indicates the operation of a vehicle S of a comparative example.

[0034] As shown in FIG. **2**, the vehicle S of the comparative example increases the engine output from an output E**0** to an output E**2** and sets the motor output to an output M**3** in a time period from the time T**1** to a time T**11**, which is shorter than a time period P**1**. With such an operation, although the vehicle S can generate an output corresponding to the required driving force, the catalyst temperature rapidly rises from a temperature C**0** to a temperature C**2**, so that ammonia slip tends to occur easily.

[0035] In contrast, in the vehicle S according to the present embodiment, the output control part **224** increases the output of the engine **6** from an output E**1** to the output E**2** and decreases the output of the motor **4** from an output M**2** to an output M**0** as the elapsed time from the time T**1** increases in the time period P**1** from the time T**1** to the time T**12**. By operating in this manner, the output control part **224** can gradually increase the engine output from the time T**1** to the time T**12** while generating the output corresponding to the required driving force of the vehicle S. As a result, since the output control part **224** can suppress the rapid rise in the temperature of the catalyst **9** as indicated by the "catalyst temperature" indicated by the dashed line in the time period from the time T**1** to the time T**11**, it is possible to suppress desorption and emission of ammonia from the catalyst **9**.

[0036] For example, the output control part **224** identifies the output corresponding to the accelerator opening degree by referencing the storage part **21**, and increases the output of the engine **6** by a predetermined change amount, taking the output corresponding to the accelerator opening degree as the maximum value, at the time elapsed from the time T**1**. Then, the output control part **224** reduces the output of the motor **4** by the predetermined change amount so that, for example, the output obtained by subtracting the output of the engine **6** from the output corresponding to the accelerator opening degree becomes the output of the motor **4**.

[0037] Specifically, in the time period P**1**, the output control part **224** increases the output of the engine **6** from the output E**1** to the output E**2** with a constant change amount, with the output E**2** corresponding to the accelerator opening degree (that is, an additional value of the output E**1** and the output M**2**) as the maximum value. Then, the output control part **224** reduces the output of the motor **4** from the output M**2** to the output M**0** (for example, 0) by the constant change amount so that a subtraction value obtained by subtracting the output of the engine **6** from the output E**2** becomes the output of the motor **4**.

[0038] By operating as described above, the output control part **224** can adjust the amount of change in the output of the engine **6** and the amount of change in the output of the motor **4** to equal change amounts. Thus, the output control part **224** can change the outputs of the engine **6** and the motor **4** at a constant ratio while generating the output corresponding to the accelerator opening degree. Furthermore, by reducing the predetermined change amount, the output control part **224** can gradually increase the output of the engine **6** and gradually decrease the output of the motor **4**.

[0039] The output control part **224** may determine the predetermined change amount on the basis of (i) the SOC of the battery **5** that supplies electricity to the motor **4** and (ii) the angle of the uphill slope, both at the time T**1**. For example, the output control part **224** reduces the predetermined change amount as the angle of the uphill slope acquired by the acquisition part **221** at the time T**1** increases. By operating in this manner, the output control part **224** can gradually decrease the output of the motor **4** while gradually increasing the output of the engine **6**, even on a steep uphill slope that requires a large output. As a result, the output control part **224** can suppress the rapid rise in the catalyst temperature, thereby suppressing desorption and emission of ammonia from the catalyst **9**.

[0040] For example, the output control part **224** reduces the predetermined change amount as the SOC of the battery **5** acquired by the acquisition part **221** at the time T**1** increases. By operating in this manner, as the SOC increases, the output control part **224** increases the electricity consumption of the motor **4**, which gradually decrease the output of the motor **4**. By this, the output control part **224** can gradually increase the output of the engine **6**.

[0041] Furthermore, the output control part **224** may determine the predetermined change amount so that the SOC is reduced to 0 while the vehicle S travels on the uphill slope. For example, the output control part **224** determines the predetermined change amount so that the SOC is reduced to 0 (SOC B**3** shown in FIG. **2**) during the time period from the time T**1** to the time T**2** shown in FIG. **2**. By operating in this manner, the output control part **224** can facilitate a gradual increase in the output of the engine **6**. Furthermore, as the SOC decreases, the battery **5** can more effectively store electricity generated by the motor **4** through regenerative braking when the vehicle S, having passed through the end position of the uphill slope, travels on a downhill slope and executes regenerative braking.

[0042] It should be noted that the output control part **224** may determine the predetermined change amount so that the SOC is reduced to a predetermined value while the vehicle S travels on an uphill slope. The predetermined value is a value greater than 0, and is the SOC for the battery **5** to supply electricity to other devices different from the motor **4**. By operating in this manner, the output control part **224** can facilitate a gradual increase of the output of the engine **6** while operating each device to which the battery **5** supplies electricity.

[0043] In order to gradually decrease the motor output at a time after the time T**1**, the motor output needs to be large at the time T**1**. Furthermore, in order to gradually increase the engine output after the time T**1**, it is necessary to minimize the amount of change in the engine output from a time before the time T**1** to the time T**1**. Therefore, the output control part **224** determines the engine output and the motor output so that the engine output does not sharply increase at the time T**1**, which is the start timing of passing through the start position of the uphill slope.

[0044] The output control part **224** determines the output of the engine **6** and the output of the motor **4** at the time T**1** on the basis of, for example, (i) the average output of the engine **6** in the time period from the time prior to the time T**1** by a predetermined time to the time T**1** and (ii) the accelerator opening degree at the time T**1**. The predetermined time is a time determined through experiment or simulation, and is, for example, 1 second.

[0045] Specifically, at the time T**1**, the output control part **224** calculates an average output E**1** of the output of the engine **6** determined to be a time period from one second before the time T**1** to the time T**1**. Then, for example, the output control part **224** determines the average output E**1** as the output of the engine **6** at the time T**1**, and determines the output M**2** obtained by subtracting the average output E**1** from an output E**2** corresponding to the accelerator opening degree at the time T**1** as the output of the motor **4** at the time T**1**.

[0046] By operating in this manner, the output control part **224** can increase the output of the motor **4** while ensuring the output of the engine **6** does not increase, all the while generating the output E**2** corresponding to the accelerator opening degree at the time T**1**. As a result, the output control part **224** can gradually increase the output of the engine **6** while gradually decreasing the output of the motor **4** at the time after the time T**1**.

[0047] In order to increase the output of the motor **4** at the time T**1** and gradually decrease the output of the motor **4** at the time after the time T**1**, the vehicle S needs to travel so to prevent the SOC of the battery **5** from decreasing at the time prior to the time T**1**. Therefore, the output control part **224** increases the output of the engine **6** at the output corresponding to the driving force required of the vehicle S and decreases the output of the motor **4** in a state where the vehicle S is traveling ahead of the uphill slope.

[0048] For example, the output control part **224** causes the engine **6** to generate a first correction output obtained by adding the correction amount to the output of the engine **6** corresponding to the accelerator opening degree and the vehicle speed at a time prior to the time T**1** as a result of the determination part **222** determining that the vehicle S will travel on the uphill slope. Then, the output control part **224** causes the motor **4** to generate a second correction output obtained by subtracting the correction amount from the output of the motor **4** corresponding to the accelerator opening degree and the vehicle speed at a time prior to the time T**1**, for example, as a result of the determination part **222** determining that the vehicle S will travel on the uphill slope.

[0049] Specifically, the output control part **224** causes the engine **6** to generate the first correction output E**1** obtained by adding the correction amount to the output E**0** of the engine **6** corresponding to the accelerator opening degree and the vehicle speed in the time period P**0** from the time T**0** to the time T**1** as shown in FIG. **2**. Then, in the time period P**0**, the output control part **224** causes the motor **4** to generate the second correction output M**0** obtained by subtracting the correction amount from an output M**1** of the motor **4** corresponding to the accelerator opening degree and the vehicle speed. By operating in this manner, the output control part **224** can adjust the SOC of the battery **5** at the time T**1** to an SOC B**1** which is larger than the SOC B**2**, and thus can suppress a decrease in the SOC of the battery **5**.

[0050] The output control part **224** determines the correction amount on the basis of, for example, the angle and distance of the uphill slope, and the SOC of the battery **5**, which are acquired by the acquisition part **221**. For example, the steeper the angle of the uphill slope, the more the output control part **224** increases the correction amount. By operating in this manner, the output control part **224** can reduce the decrease in the SOC at a time prior to the time T**1** to a smaller extent as the slope becomes steeper. As a result, the steeper the uphill slope, the more the output control part **224** can increase the amount of electricity to be supplied to the motor **4** at the time after the time T**1**. This enables the output control part **224** to gradually decrease the output of the motor **4**.

[0051] For example, the longer the distance of the uphill slope, the more the output control part **224** increases the correction amount. By operating in this manner, the output control part **224** can reduce the decrease in the SOC at a time prior to the time T**1** as the traveling distance on the uphill slope becomes longer. This enables the output control part **224** to increase the time period for which the motor **4** generates the output, as the distance of the uphill slope becomes longer. The lower the SOC of the battery **5**, the more output control part **224** increases the correction amount, for example. By operating in this manner, the output control part **224** can prevent a shortage of the SOC of the battery **5** at the time T**1**.

[0052] In the time period P**0** shown in FIG. **2**, an operation is exemplified where the engine **6** generates the first correction output E**1** and the motor **4** generates the second correction output M**0**, but the present embodiment is not limited to this operation. The output control part **224** may change the first correction output and the second correction output with the passage of time in the time period P**0**. FIG. **3** shows changes in the engine output and motor output in the time period P**0**. In FIG. **3**, the values indicated by the solid lines for the "motor output," "engine output," and "catalyst temperature" in the time period P**0** differ from the values shown in FIG. **2**, and all other aspects remain the same.

[0053] As shown in FIG. **3**, for example, the output control part **224** increases the correction amount at a time prior to the time T**1**, which is the start timing, as the time elapsed from the time T**0**, which is the determination timing at which the determination part **222** determined that the vehicle S will travel on the uphill slope, increases. Specifically, the output control part **224** increases the correction amount as the time elapsed from the time T**0** increases in the time period P**0**, thereby increasing the output of the engine **6** from the output E**0** to the output E**1** while reducing the output of the motor **4** from the output M**1** to the output M**0**. By operating in this manner, the output control part **224** can suppress a rapid increase in the engine output or a rapid decrease in the motor output at the time T**0**. Furthermore, since the output control part **224** can reduce the amount of change in the engine output at the time T**1**, it can facilitate a gradual increase in the engine output.

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

[0054] FIG. **4** shows an example of a processing sequence in the power determination apparatus **20**. The processing sequence shown in FIG. **4** shows an operation of the power determination apparatus **20** determining the output of the engine **6** and the output of the motor **4** when the vehicle S, traveling on a flat road, continues to travel to the end position of the uphill slope located ahead in the traveling direction.

[0055] The acquisition part **221** acquires the travel route and the position of the vehicle S from the receiving device **1** (S**11**). The acquisition part **221** identifies, on the basis of the position of the vehicle S, a start position of an uphill slope that is located ahead of the vehicle S in the traveling direction and has the shortest distance from the vehicle S, from among start positions of a plurality of uphill slopes included in the traveling route of the vehicle S (S**12**).

[0056] The determination part **222** determines whether the vehicle S will travel on the uphill slope that includes the identified start position (S**13**). If a branch point exists between the start position of the uphill slope and the position of the vehicle S, the determination part **222** determines that there is a possibility the vehicle S will not travel on the uphill slope (NO in S**13**). Then, the power determination apparatus **20** returns to the process of step S**11**.

[0057] If no branch point exists between the start position of the uphill slope and the position of the vehicle S, the determination part **222** determines that the vehicle S will travel on the uphill slope (YES in S**13**). Then, the output control part **224** calculates a correction amount for the output on the basis of the angle and distance of the gradient included in the travel route and the SOC of the battery **5**, which are acquired by the acquisition part **221** (S**14**).

[0058] The output control part **224** calculates a first correction output obtained by adding the calculated correction amount to the output of the engine **6** corresponding to the accelerator opening degree and the vehicle speed, and calculates a second correction output obtained by subtracting the calculated correction amount from the output of the motor **4** corresponding to the accelerator opening degree and the vehicle speed (S**15**).

[0059] If the detection part **223** does not detect that the vehicle S has passed the start position of the uphill slope (NO in S**16**), the output control part **224** returns to the process of step S**15**.

[0060] If the detection part **223** detects that the vehicle S has passed through the start position of the uphill slope (YES in S**16**), the output control part **224** calculates an average output of the outputs of the engine **6** from a time prior to the current time by a predetermined amount of time to the current time and identifies the accelerator opening degree (S**17**). The output control part **224** then determines the calculated average output as the output of the engine **6**, and determines, as the output of the motor **4**, a subtraction value obtained by subtracting the average output from the output corresponding to the accelerator opening degree (S**18**). Then, the output control part **224** generates the output of the engine **6** and the output of the motor **4** as determined in the process of step S**18**.

[0061] The output control part **224** calculates the amount of change in the output of the engine **6** and the output of the motor **4** on the basis of the angle and distance of the uphill slope, and the SOC of the battery **5**, which are acquired by the acquisition part **221** (S**19**). If the SOC of the battery **5** is equal to or greater than a predetermined amount (YES in S**20**), the output control part **224** subtracts the amount of change from the motor output at a time prior to the current time by the control cycle (S**21**), and determines, as the motor output at the current time, a subtraction value obtained by subtracting the amount of change from said motor output. The predetermined amount is an amount greater than or equal to 0 and less than the maximum value of the motor output. If the SOC of the battery **5** is less than the predetermined amount (NO in S**20**), the output control part **224** determines the motor output at a time prior to the current time by the control cycle as the motor output at the current time, without subtracting the amount of change from the motor output, and proceeds to step S**22**.

[0062] If the engine output at the time prior to the current time by the control cycle is less than a predetermined value (YES in S**22**), the output control part **224** adds the change amount to the engine output (S**23**), and determines, as the engine output at the current time, an addition value obtained by adding the change amount to the engine output. The predetermined value is an output corresponding to the accelerator opening degree. If the engine output at the time prior to the current time by the control cycle is equal to or greater than the predetermined value (NO in S**22**), the output control part **224** determines the engine output at the time prior to the current time by the control cycle as the engine output at the current time, and proceeds to step S**24**. Then, the output control part **224** causes the engine **6** to generate the determined engine output, and causes the motor **4** to generate the determined motor output.

[0063] The detection part **223** detects an end timing at which the vehicle S finishes traveling on the uphill slope, for example, on the basis of the end position of the uphill slope and the position of the vehicle S included in the traveling route acquired by the acquisition part **221** (S**24**). If the detection part **223** does not detect the end timing, that is, if the vehicle S has not finished traveling on the uphill slope (NO in S**24**), the power determination apparatus **20** repeats the processes from step S**20** to step S**23**. If the detection part **223** detects the end timing, that is, if the vehicle S has finished traveling on the uphill slope (YES in S**24**), the power determination apparatus **20** ends the process.

Modification Example

[0064] In the above description, the operation in which the output control part **224** determines the correction amounts for the outputs of the engine **6** and the motor **4** in the time period from the determination timing at which the determination part **222** determines that the vehicle S will travel on the uphill slope to the start timing at which the vehicle S passes through the start position of the uphill slope is described, but the present embodiment is not limited to this. The output control part **224** may determine the first correction output and the second correction output by correcting the ratio (distribution) between the output of the engine **6** and the output of the motor **4** within the required output corresponding to the driving force required of the vehicle S.

[0065] FIG. **5** shows an operation of correcting a ratio of outputs between the engine **6** and the motor **4**. FIG. **5** shows the power distribution map N**1** and a power distribution correction map N**2**, which are stored in the storage part **21**. The power distribution map N**1** indicates the distribution (ratio of required outputs) between the output of the engine **6** and the output of the motor **4** corresponding to the accelerator opening degree and the vehicle speed. The power distribution correction map N**2** indicates correction values for the distribution of the output of the engine **6** and the output of the motor **4** based on gradient information and the SOC of the battery **5**. The gradient information includes the angle and distance of the gradient, which are acquired by the acquisition part **221**. The power distribution correction map N**2** indicates correction values for increasing the output of the engine **6** and decreasing the output of the motor **4** as the angle and distance of the gradient increase and the SOC of the battery **5** decreases.

[0066] By referencing the power distribution map N**1** stored in the storage part **21**, the output control part **224** identifies a distribution (power distribution) between the output of the engine **6** and the output of the motor **4** corresponding to the accelerator opening degree and the vehicle speed ((1) shown in FIG. **5**). By referencing the power distribution correction map N**2** stored in the storage part **21**, the output control part **224** identifies a correction value corresponding to the angle and distance of the gradient, and the SOC of the battery **5** ((2) shown in FIG. **5**). The output control part **224** determines a correction power distribution obtained by adding the correction value to the power distribution ((3) shown in FIG. **5**), and determines the output of the engine **6** and the output of the motor **4** corresponding to the determined correction power distribution.

[0067] For instance, the output control part **224** identifies an engine output of “0.6” and a motor output of “0.4” as the power distribution, and identifies “0.2” as the correction value. The output control part **224** then sets, as the correction power distribution of the engine output, the addition value “0.8”, which is obtained by adding the correction value “0.2” to the power distribution “0.6” of the engine output, and identifies the power distribution “0.4” of the motor output as the correction power distribution of the motor output. In other words, the output control part **224** causes the engine **6** to generate two thirds of the output corresponding to the required driving force, and causes the motor **4** to generate one third of the output corresponding to the required driving force.

[0068] By operating in this manner, the output of the engine **6** and the output of the motor **4** can be determined on the basis of the angle and distance of the gradient of the road on which the vehicle S travels, and the SOC of the battery **5**, without requiring the determination part **222** to determine whether the vehicle S will travel on an uphill slope. It should be noted that in a case where the determination part **222** has determined that the vehicle S will not travel on an uphill slope, the output control part **224** may determine the outputs of the engine **6** and the motor **4** by referencing the power distribution map N**1**. On the other hand, in a case where the determination part **222** has determined that the vehicle S will travel on an uphill slope, the output control part **224** may determine the outputs of the engine **6** and the motor **4** by referencing both the power distribution map N**1** and the power distribution correction map N**2**.

Effects of the Vehicle S

[0069] As described above, the vehicle S includes the detection part **223** that detects the start timing at which the vehicle S passes through the start position of the uphill slope, and the output control part **224** that increases the output of the engine **6** and decreases the output of the motor **4** as the time elapsed from the start timing increases. By configuring the vehicle S in this manner, the vehicle S can gradually increase the output of the engine **6** while generating an output corresponding to the required driving force in traveling on a road with an uphill slope. As a result, since the vehicle S can suppress a rapid rise in the temperature of the catalyst **9** due to a rapid increase in the output of the engine **6**, it is possible to suppress the ammonia adsorbed on the catalyst **9** from being desorbed and emitted.

[0070] 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 that comprises an engine and a motor as drive sources, the hybrid vehicle comprising: a detection part that detects a start timing at which the hybrid vehicle passes through a start position of an uphill slope; and an output control part that increases an output of the engine and decreases an output of the motor as a time elapsed from the start timing increases.
2. The hybrid vehicle according to claim 1, wherein the output control part increases the output of the engine by a predetermined change amount, taking an output corresponding to an accelerator opening degree as a maximum value, at the time elapsed from the start timing, and reduces the output of the motor by the predetermined change amount so that an output obtained by subtracting the output of the engine from the output corresponding to the accelerator opening degree becomes the output of the motor.
3. The hybrid vehicle according to claim 2, wherein the output control part determines the predetermined change amount on the basis of (i) a state of charge stored in a power storage device that supplies electricity to the motor and (ii) the angle of the uphill slope, both measured at the start timing.
4. The hybrid vehicle according to claim 3, wherein the output control part reduces the predetermined change amount as the angle of the uphill slope increases.
5. The hybrid vehicle according to claim 3, wherein the output control part reduces the predetermined change amount as the state of charge increases.
6. The hybrid vehicle according to claim 3, wherein the output control part determines the predetermined change amount so that the state of charge is reduced to 0 while the hybrid vehicle travels on the uphill slope.
7. The hybrid vehicle according to claim 1, wherein the output control part determines the output of the engine and the output of the motor at the start timing on the basis of (i) an average output of the engine in a time period from the time prior to the start timing by a predetermined time to the start timing and (ii) an accelerator opening degree at the start timing.
8. The hybrid vehicle according to claim 7, wherein the output control part determines the average output as the output of the engine at the start timing, and determines an output obtained by subtracting the average output from an output corresponding to the accelerator opening degree at the start timing as the output of the motor at the start timing.
9. The hybrid vehicle according to claim 1, further comprising: a determination part that determines that the hybrid vehicle will travel on the uphill slope when no branch point of a road exists between the position of the hybrid vehicle and the start position at a time prior to the start timing.
10. The hybrid vehicle according to claim 9, wherein the output control part causes the engine to generate a first correction output obtained by adding a correction amount to the output of the engine corresponding to the accelerator opening degree and the vehicle speed, and causes the motor to generate a second correction output obtained by subtracting the correction amount from the output of the motor corresponding to the accelerator opening degree and the vehicle speed, at a time prior to the start timing as a result of the determination part determining that the vehicle will travel on the uphill slope.
11. The hybrid vehicle according to claim 10, wherein the output control part increases the correction amount at a time prior to the start timing as the time elapsed from a determination timing, at which the determination part determined that the vehicle will travel on the uphill slope increases.
12. The hybrid vehicle according to claim 10, wherein the steeper the angle of the uphill slope, the

more the output control part increases the correction amount.

13. The hybrid vehicle according to claim 10, wherein the longer a distance of the uphill slope, the more the output control part increases the correction amount.

14. The hybrid vehicle according to claim 1, wherein the detection part detects, as the start timing, a timing at which a subtraction value, obtained by subtracting a second accelerator opening degree at a time prior to the current time by a predetermined time from a first accelerator opening degree at the current time, is equal to or greater than a predetermined value.