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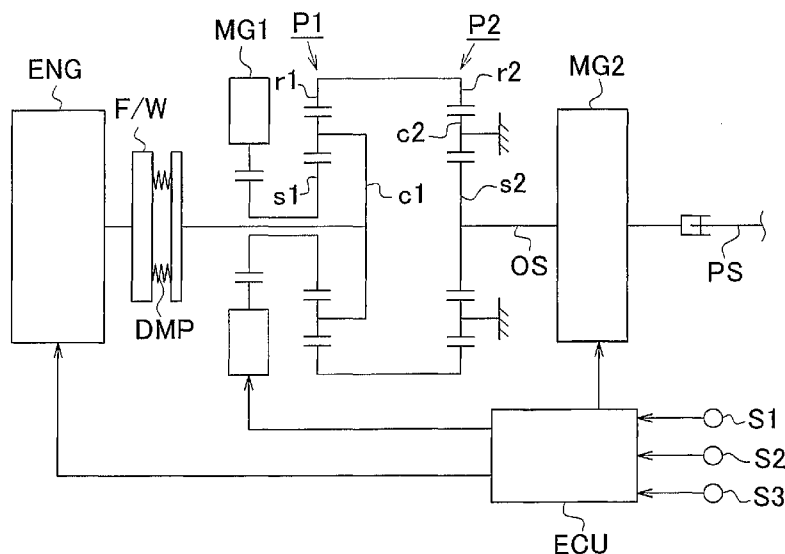
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[Continued on next page]

- (54) Title:** CONTROL APPARATUS AND CONTROL METHOD FOR VEHICLE

FIG. 1



(57) Abstract: A control apparatus for a vehicle executes gear rattle noise suppression control that suppresses gear rattle noise of gears provided in a transaxle by increasing the speed of an engine (ENG). The control apparatus decreases the output of the engine (ENG) when the gear rattle noise suppression control is executed.



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CONTROL APPARATUS AND CONTROL METHOD FOR VEHICLE

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The invention relates to a control apparatus and a control method for a vehicle, that executes gear rattle noise suppression control that suppresses gear rattle noise in a transaxle by changing the operating point of an engine so that the engine speed increases.

2. Description of the Related Art

[0002] In recent years, hybrid vehicles provided with two driving sources, i.e., an engine and an electric motor, have been put to practical use in an attempt to improve fuel efficiency and emissions and the like. Some hybrid vehicles are provided with a power split device formed by a planetary gear set. A hybrid vehicle having such a power split device is able to distribute engine output to a drive shaft and the electric motor and generate electric power while the vehicle is running using some of the engine output, combine the engine output with the electric motor output and then output that combined output to the drive shaft, and apply braking force by regenerating electric power in the electric motor using the power of the drive shaft when braking the vehicle.

[0003] Also, one such hybrid vehicle having a power split device that also has another electric motor (i.e., a second electric motor) on the drive shaft side of the power split device, in addition to the electric motor described above (i.e., the first electric motor), and in which the vehicle is run by controlling the powering and regenerating of these two electric motors, has been proposed. This kind of hybrid vehicle can be run in various operating modes, such as an overdrive mode, an accelerating mode, and a braking mode, for example. The overdrive mode is a mode in which the drive shaft is driven at low speed and high torque by regenerating electric power with the first electric motor and

driving the second electric motor with that regenerated electric power. The accelerating mode is a mode in which good acceleration is achieved by powering both electric motors. The braking mode is a mode in which braking force is applied to the drive shaft by regenerating electric power with one or both electric motors, with the braking force corresponding to the amount of energy regenerated.

[0004] Furthermore, a hybrid vehicle has also been proposed that employs an electric torque converter that couples an engine output shaft to one shaft (such as a ring gear shaft) of a planetary gear set, couples an electric motor to another shaft (such as a sun gear shaft) of the planetary gear set, and couples the remaining shaft (such as a carrier shaft) of the planetary gear set to the drive shaft. When this kind of electric torque converter is placed in a no-load state in which no electricity flows through the three-phase coil of the electric motor, the carrier shaft will rotate idly so no power will be output even if the engine is running. When starting to regenerate current from this state, such that current gradually flows through the three-phase coil of the electric motor, braking force corresponding to the regenerated current is generated on the sun gear shaft. Therefore, engine torque will be boosted and output to the drive shaft.

[0005] Incidentally, in a hybrid vehicle provided with such a power split device and electric torque converter, gear rattle noise referred to as a rattling noise is produced by the gear mechanism of the transaxle, such as a planetary gear set. This kind of gear rattle noise is produced by the repeated striking and separating of gear teeth, which are separated a small space when two gears are in mesh, due to fluctuations in the power that drives the gears.

[0006] Therefore, as is evident in Japanese Patent Application Publication No. 11-093725 (JP-A-11-093725) and Japanese Patent Application Publication No. 2008-201351 (JP-A-2008-201351), a control apparatus for a vehicle has been proposed suppresses gear rattle noise by changing the operating point of the engine (i.e., the engine speed and the engine torque) to increase the engine speed when the gear rattle noise occurs in the transaxle. FIG. 6 is a graph showing the change in the engine operating point during gear rattle noise suppression control of a related control apparatus of a

vehicle. The normal operation line shown in FIG. 6 is a line created by plotting the engine operating point at each engine output during normal operation. Also, the gear rattle noise suppression line in FIG. 6 is a line created by plotting the engine operating point at which gear rattle noise can be suppressed at each engine output. Gear rattle noise is able to be suppressed by changing the operating point of the engine from the normal operation line to the gear rattle noise suppression line. In this related control apparatus for a vehicle, when gear rattle noise suppression control is executed, the engine operating point is changed from a point on the normal operation line to a point on the gear rattle noise suppression line along a constant power line where engine output becomes constant, so that the engine output will not change. Incidentally, the optimum fuel efficiency line shown in FIG. 6 is a line created by plotting the engine operating point at which fuel efficiency is maximized at each engine output.

[0007] Incidentally, if the engine speed is changed greatly when this kind of gear rattle noise suppression control is executed, the engine noise may change which may bother the driver. Therefore, in a vehicle in which gear rattle noise suppression control is performed, the normal operation line of the engine is forced to be set somewhat close to the gear rattle noise suppression line, and as a result, the normal operation line of the engine becomes farther away from the optimum fuel efficiency line, such that fuel efficiency ends up decreasing.

SUMMARY OF THE INVENTION

[0008] This invention therefore proposes a control apparatus and a control method for a vehicle, that is capable of suppressing gear rattle noise in a transaxle, while also inhibiting a decrease in fuel efficiency.

[0009] A first aspect of the invention relates to a control apparatus for a vehicle. This control apparatus for a vehicle executes gear rattle noise suppression control that suppresses gear rattle noise of gears provided in a transaxle by increasing engine speed, and decreases engine output when executing the gear rattle noise suppression control. Also, the control apparatus may change an operating point of an engine such that the

engine speed increases and the engine output decreases, when executing the gear rattle noise suppression control. Furthermore, when executing the gear rattle noise suppression control, the control apparatus may change the operating point such that the engine output decreases with respect to a constant power line of the engine immediately before the gear rattle noise suppression control is executed.

[0010] When the engine output is decreased during the gear rattle noise suppression control (i.e., when the engine operating point is changed such that the engine output decreases during the gear rattle noise suppression control), or when the engine output is changed to the side where the engine output decreases with respect to the constant power line of the engine immediately before the gear rattle noise suppression control is executed, the amount of change in the engine speed to a gear rattle noise suppression line (see FIGS. 2 and 3) is able to be made smaller than it can when the engine output is kept constant during gear rattle noise suppression control (i.e., that is can when the engine operating point is changed while keeping the engine output constant during gear rattle noise suppression control). In other words, a normal operation line can be set farther away from the gear rattle noise suppression line, i.e., closer to an optimum fuel efficiency line (see FIG. 3). Therefore, this structure enables gear rattle noise in the transaxle to be suppressed while inhibiting a decrease in fuel efficiency.

[0011] Incidentally, when gear rattle noise suppression control is performed, the engine output, and thus the driving force of the vehicle, will decrease with the execution of that gear rattle noise suppression control. Therefore, the vehicle may be a hybrid vehicle provided with the engine and an electric motor as driving sources, and the control apparatus may compensate for a decrease in engine torque that occurs when the gear rattle noise suppression control is executed by increasing the torque of the electric motor. This kind of structure enables the driving force of the vehicle to be maintained.

[0012] Also, it is possible to deal with the decrease in driving force of the vehicle that occurs when the gear rattle noise suppression control is executed by having the driver to simply depress the accelerator pedal further. However, in this case as well, problems such as those described below arise. That is, in the vehicle, the required

driving force of the vehicle is estimated based on the detected accelerator operation amount by the driver, and that estimated required driving force of the vehicle is used in vehicle control such as shift control. However, when gear rattle noise suppression control is executed such that the engine output decreases, the generated engine torque decreases compared with when that gear rattle noise suppression control is not executed, even though the accelerator operation amount is the same. Therefore, when gear rattle noise suppression control is executed, the required driving force of the vehicle that is estimated from the accelerator operation amount may not match the actual required driving force of the vehicle. Therefore, the control apparatus may also include a required driving force calculating portion that calculates a required driving force of the vehicle based on an accelerator operation amount, and when the gear rattle noise suppression control is executed, the required driving force calculating portion may calculate the required driving force to be smaller according to the decrease in the engine torque that occurs when the gear rattle noise suppression control is executed. This kind of structure enables the estimated required driving force of the vehicle to match the actual required driving force of the vehicle even when gear rattle noise suppression control is executed.

[0013] Incidentally, in a vehicle provided with an electric motor directly connected to an output shaft of the transaxle, the kind of gear rattle noise of the gears in the transaxle described above tends to occur when the torque of the electric motor is equal to or less than a predetermined value, or more particularly, is close to zero. Therefore, the vehicle may be provided with an electric motor that is directly connected to an output shaft of the transaxle, and the gear rattle noise suppression control may be executed when the torque of the electric motor becomes equal to or less than a predetermined value, or more particularly, is close to zero. The control apparatus described above is preferably applied to a vehicle provided with an electric motor that is directly connected to an output shaft of the transaxle, and in which gear rattle noise suppression control is executed when the torque of the electric motor becomes equal to or less than a predetermined value, or more particularly, is close to zero.

[0014] A second aspect of the invention relates to a control apparatus for a vehicle. This control apparatus includes a control portion that executes gear rattle noise suppression control that suppresses gear rattle noise of gears provided in a transaxle by increasing engine speed. The control portion decreases engine output when executing the gear rattle noise suppression control.

[0015] A third aspect of the invention relates to a control method for a vehicle. This control method includes executing gear rattle noise suppression control that suppresses gear rattle noise of gears provided in a transaxle by increasing engine speed, and decreasing engine output when executing the gear rattle noise suppression control.

[0016] In this control method, an operating point of an engine may be changed such that the engine speed increases and the engine output decreases, when the gear rattle noise suppression control is executed. In the control method, when the gear rattle noise suppression control is executed, the operating point may be changed such that the engine output decreases with respect to a constant power line of the engine immediately before the gear rattle noise suppression control is executed. In the control method, the vehicle may be a hybrid vehicle provided with the engine and an electric motor as driving sources, and a decrease in engine torque that occurs when the gear rattle noise suppression control is executed may be compensated for by increasing the torque of the electric motor. The control method may also include calculating a required driving force of the vehicle based on an accelerator operation amount, and when the gear rattle noise suppression control is executed, the required driving force may be calculated to be smaller according to a decrease in an engine torque value that occurs when the gear rattle noise suppression control is executed. In the control method, the vehicle may be provided with an electric motor that is directly connected to an output shaft of the transaxle, and the gear rattle noise suppression control may be executed when the torque of the electric motor becomes equal to or less than a predetermined value. In this control method, the predetermined value may be close to zero.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The features, advantages, and technical and industrial significance of this invention will be described in the following detailed description of example embodiments of the invention with reference to the accompanying drawings, in which like numerals denote like elements, and wherein:

FIG. 1 is a block diagram schematically showing a frame format of the structure of a drive system of a hybrid vehicle to which a first example embodiment of the control apparatus for a vehicle according to the invention is applied;

FIG. 2 is a graph showing the settings of the engine operating point during gear rattle noise suppression control according to both the first example embodiment of the invention and the related art;

FIG. 3 is a graph showing the settings of the normal operation line of the engine according to both the first example embodiment of the invention and the related art;

FIG. 4 is a flowchart illustrating the steps in a gear rattle noise suppression control routine employed in the first example embodiment of the invention;

FIG. 5 is a flowchart illustrating the steps in a gear rattle noise suppression control routine employed in a second example embodiment the control apparatus for a vehicle according to the invention; and

FIG. 6 is a graph showing the change in the engine operating point during gear rattle noise suppression control of a related control apparatus for a vehicle.

DETAILED DESCRIPTION OF EMBODIMENTS

[0018] A first example embodiment, which is only one example embodiment of the control apparatus for a vehicle according to the invention, will be described in detail below with reference to the FIGS. 1 to 4. FIG. 1 is a block diagram of the structure of a drive system of a hybrid vehicle to which a control apparatus for a vehicle according to this example embodiment is applied. As shown in the drawing, this hybrid vehicle is provided with an engine ENG and two electric motors (i.e., a first electric motor MG1 and a second electric motor MG2) as drive sources of the vehicle. Also, a transaxle of this hybrid vehicle includes two planetary gear sets, i.e., a front planetary gear set P1 and

a rear planetary gear set P2, that function as a power split device and an electric torque converter.

[0019] As shown in the drawing, the output shaft of the engine ENG is connected to a carrier c1 of the front planetary gear set P1 that is formed of three rotating elements, i.e., a sun gear s1, the carrier c1, and a ring gear r1, via a flywheel F/W and a damper DMP. The sun gear s1 of this front planetary gear set P1 is connected to a rotor of the first electric motor MG1 so as to be able to rotate together with the rotor. Also, the ring gear r1 of the front planetary gear set P1 is connected to a ring gear r2 of the rear planetary gear set P2 so as to be able to rotate together with the ring gear r2. The ring planetary gear set P2 has a sun gear s2 that is connected to an output shaft OS of the transaxle, and thus a propeller shaft PS that serves as the drive shaft of the hybrid vehicle, so as to be able to rotate together with the output shaft OS or the propeller shaft PS, and a carrier c2 that is fixed so as not to rotate. A rotor of the second electric motor MG2 is connected to the propeller shaft PS so as to be able to rotate together with the propeller shaft PS.

[0020] The engine ENG, the first electric motor MG1, and the second electric motor MG2 of this hybrid vehicle are controlled by an electronic control unit ECU. This electronic control unit ECU is connected to various sensors, such as an NE sensor S1 that detects the engine speed, a vehicle speed sensor S2 that detects the vehicle speed, and an accelerator sensor S3 that detects an accelerator operation amount by the driver. The electronic control unit ECU controls the engine ENG, the first electric motor MG1, and the second electric motor MG2 based on the running conditions of the hybrid vehicle as detected by these sensors.

[0021] Further, in this kind of hybrid vehicle, gear rattle noise of the gears that form the front planetary gear set P1 and the rear planetary gear set P2 tends to occur when the torque of the second electric motor MG2 is close to zero. This gear rattle noise is able to be suppressed by changing the operating point of the engine ENG defined by the engine speed and engine torque to the high speed, low torque side. Therefore, when the torque of the second electric motor MG2 is close to zero, the electronic control

unit ECU attempts to suppress the gear rattle noise by changing the operating point of the engine ENG so that the engine speed increases.

[0022] At this time, when gear rattle noise suppression control is executed with the control apparatus for a vehicle in the related art, the operating point of the engine ENG is changed along a constant power line where engine output becomes constant, so that the engine output will not change. That is, the operating point of the engine ENG is changed along the constant power line from point A on a normal operation line to point B on a gear rattle noise suppression line, as shown by the solid line in FIG. 2.

[0023] In contrast, when gear rattle noise suppression control is executed at this time with the control apparatus for a vehicle according to this example embodiment, the operating point of the engine ENG changes such that the engine output decreases. That is, in this example embodiment, the operating point of the engine ENG is changed from point A on the normal operation line to point C on the side where the engine output decreases with respect to the constant power line of the engine ENG which passes through point A, as shown by the dotted line in FIG. 2.

[0024] This control apparatus for a vehicle according to this example embodiment is able to suppress gear rattle noise in the transaxle while also inhibiting a decrease in fuel efficiency. The reason for this will now be described.

[0025] If the point that the engine ENG is to be changed to (i.e., the target change point) during gear rattle noise suppression control is changed from point A on the constant power line to point C where the engine output decreases, the amount of change in the engine speed from this gear rattle noise suppression control decreases, as shown in FIG. 2. Incidentally, as described above, there is a limit to the amount that the engine speed can be changed during gear rattle noise suppression control. Therefore, as shown by the solid line in FIG. 3, the normal operation line of the engine ENG is forced to be set somewhat close to the gear rattle noise suppression line, and as a result, the normal operation line of the engine ENG becomes farther away from the optimum fuel efficiency line, such that fuel efficiency may end up decreasing.

[0026] In contrast, with the control apparatus for a vehicle according to this first

example embodiment, when the same operating point as described above is used as the starting point and the operating point of the engine ENG is then changed, the amount of change in the engine speed during gear rattle noise suppression control is less than it is in the related art. In other words, if the amount of change in the engine speed during gear rattle noise suppression control is the same, the starting point can be set closer to the optimum fuel efficiency line than it can be with the related art. Therefore, as shown by the alternate long and short dash line in FIG. 3, this first example embodiment enables the normal operating line of the engine ENG to be set closer to the optimum fuel efficiency line than the related art does, thus making it possible to inhibit a decrease in fuel efficiency that would otherwise occur in order to enable gear rattle noise suppression control to be executed.

[0027] Incidentally, when gear rattle noise suppression control is performed in this way, the engine output, and thus the driving force of the vehicle, will decrease with the execution of that gear rattle noise suppression control. Therefore, in this example embodiment, the driving force of the vehicle is maintained by compensating for a decrease in engine torque that occurs when this gear rattle noise suppression control is executed by increasing the torque from the second electric motor MG2.

[0028] FIG. 4 is a flowchart illustrating a gear rattle noise suppression control routine employed in the first example embodiment. This routine is executed repeatedly in cycles by the electronic control unit ECU while the vehicle is running.

[0029] Now when the routine starts, the electronic control unit ECU first determines in step S101 whether a gear rattle noise occurrence condition is satisfied, i.e., whether the conditions are such that gear rattle noise of the gears in the transaxle is likely to occur. More specifically, in this example embodiment, if the torque T_m generated by the second electric motor MG2 is equal to or less than a specified determining value T_{m1} , it is determined that the conditions are such that gear rattle noise is likely to occur. Here, if it is determined that the conditions are not such that gear rattle noise is likely to occur (i.e., NO in step S101), then the electronic control unit ECU immediately ends this cycle of the routine.

[0030] If, on the other hand, there is a possibility that the gear rattle noise will occur (i.e., YES in step S101), the electronic control unit ECU then calculates the engine speed N_e and engine torque T_e at which the gear rattle noise can be suppressed, i.e., the operating point of the engine at which the gear rattle noise can be suppressed, in steps S102 and S103. The engine speed N_e at this time is calculated using a two-dimensional map with the vehicle speed Spd and the engine output P_e , while the engine torque T_e is calculated using a two-dimensional map with the vehicle speed Spd and the thus calculated engine speed N_e . Incidentally, the operating point (i.e., N_e and T_e) of the engine ENG that is the control target at this time is set so that the engine output decreases, as described above.

[0031] Continuing on, in step S104, the electronic control unit ECU then calculates the amount of decrease in the torque of the propeller shaft PS following the change in the operating point, and then calculates the torque to be generated by the second electric motor MG2 that is able to compensate for that amount of decrease (i.e., calculates compensation torque T_m). In this case, this compensation torque T_m is calculated using the expression below. Incidentally, in the expression below, p_r represents the planetary gear ratio of the rear planetary gear set P2, and p_f represents the planetary gear ratio of the front planetary gear set P1. Also, T_{pc} represents the torque required at the propeller shaft PS, i.e., the required propeller shaft torque.

$$T_m = -1 / p_r \times \{T_{pc} - 1 / (1 + p_f) \times T_e\}$$

[0032] After calculating the torque T_m to be generated by the second electric motor MG2, the electronic control unit ECU then ends this cycle of the routine. Incidentally, after that, the ECU controls the engine ENG to the operating point dictated by the engine speed N_e and the engine torque T_e calculated in steps S102 and S103 above, and controls the second electric motor MG2 such that the compensation torque T_m calculated in step S104 is obtained.

[0033] The control apparatus for a vehicle in this first example embodiment described above is able to display the following effects.

- (1) In the first example embodiment, gear rattle noise suppression control that

changes the operating point of the engine ENG so that the engine speed increases is executed to suppress the gear rattle noise of gears provided in a transaxle of the vehicle. In this example embodiment, when executing the gear rattle noise suppression control at this time, the operating point of the engine ENG is changed so that the engine output decreases. That is, in this example embodiment, when executing the gear rattle noise suppression control at this time, the operating point of the engine ENG is changed to the side on which the engine output is decreased with respect to the constant power line of the engine ENG immediately before that gear rattle noise suppression control is executed. When the operating point of the engine ENG is changed so that the engine output decreases, or to the side where the engine output is decreased with respect to the constant power line of the engine ENG immediately before the gear rattle noise suppression control is executed, the amount of change in the engine speed to the gear rattle noise suppression line is less than it is when the engine operating point is changed while maintaining a constant engine output. In other words, the normal operation line can be set farther away from the gear rattle noise suppression line, i.e., closer to the optimum fuel efficiency line. Therefore, this first example embodiment enables gear rattle noise in the transaxle to be suppressed while inhibiting a decrease in fuel efficiency.

[0034] (2) In this first example embodiment, a decrease in engine torque that occurs when the gear rattle noise suppression control is executed is compensated for by increasing the torque T_m generated by the second electric motor MG2. Therefore, the driving force of the vehicle can be maintained even though the engine output decreases as a result of executing the gear rattle noise suppression control.

[0035] Continuing on, a second example embodiment of the control apparatus for a vehicle according to the invention will be described with reference to FIG. 5 as well, with a focus on the differences from the first example embodiment.

[0036] In the first example embodiment, the driving force of the vehicle is maintained by compensating for the decrease in engine torque that occurs when the gear rattle noise suppression control is executed by increasing the torque T_m generated by the second electric motor MG2. Of course, it is possible to deal with the decrease in driving

force of the vehicle that occurs when the gear rattle noise suppression control is executed by having the driver to simply depress the accelerator pedal further. In this case, when the gear rattle noise suppression control is executed, the driving force of the vehicle will naturally decrease unless the driver depresses the accelerator pedal further.

[0037] However, in this case, problems such as those described below arise. That is, in the vehicle, the required driving force of the vehicle is estimated based on the detected accelerator operation amount $Acc\theta$ by the driver, and the estimated required driving force of the vehicle is used in vehicle control such as shift control and the like. However, when gear rattle noise suppression control is executed such that the engine output decreases, the generated engine torque decreases compared with when that gear rattle noise suppression control is not executed, even though the accelerator operation amount $Acc\theta$ is the same. Therefore, when gear rattle noise suppression control is executed, the required driving force of the vehicle that is estimated from the accelerator operation amount $Acc\theta$ may not match the actual required driving force of the vehicle.

[0038] Therefore, in this second example embodiment, the electronic control unit ECU calculates the required driving force of the vehicle based on the accelerator operation amount $Acc\theta$, and calculates the required driving force to be lower according to the decrease in the engine torque that occurs when the gear rattle noise suppression control is executed. As a result, deviation between the required driving force of the vehicle that is estimated from the accelerator operation amount $Acc\theta$ and the actual required driving force of the vehicle can be avoided.

[0039] FIG. 5 is a flowchart illustrating gear rattle noise suppression control employed in this second example embodiment. This routine is also executed repeatedly in cycles by the electronic control unit ECU while the vehicle is running.

[0040] Now when this routine starts, the electronic control unit ECU first determines in step S201 whether the conditions are such that gear rattle noise of the gears in the transaxle is likely to occur. More specifically, in this example embodiment, if the torque T_m generated by the second electric motor MG2 is equal to or less than a specified determining value T_{m1} , it is determined that the conditions are such that gear rattle noise

is likely to occur. Here, if it is determined that the conditions are not such that gear rattle noise is likely to occur (i.e., NO in step S201), then the electronic control unit ECU immediately ends this cycle of the routine.

[0041] If, on the other hand, there is a possibility that the gear rattle noise will occur (i.e., YES in step S201), the electronic control unit ECU then calculates the engine speed N_e and engine torque T_e at which the gear rattle noise can be suppressed, i.e., the operating point of the engine at which the gear rattle noise can be suppressed, in steps S202 and S203. The engine speed N_e at this time is calculated using a two-dimensional map with the vehicle speed Spd and the engine output P_e , while the engine torque T_e is calculated using a two-dimensional map with the vehicle speed Spd and the thus calculated engine speed N_e . Incidentally, the operating point (i.e., N_e and T_e) of the engine ENG that is the control target at this time is set so that the engine output decreases, as described above.

[0042] Then in step S204, the electronic control unit ECU calculates the required driving force T_{dc} of the vehicle so that it is a smaller value than normal by the amount of decrease in the engine torque that occurs when the gear rattle noise suppression control is executed. The required driving force T_{dc} at this time is calculated using a two-dimensional map T_{dc_map} with the vehicle speed Spd and the accelerator operation amount $Acc\theta$. The required driving force T_{dc} calculated here is used in various vehicle controls such as shift control, as a parameter indicative of a demand by the driver for driving force of the vehicle. After calculating this required driving force T_{dc} , the electronic control unit ECU then ends this cycle of the routine. Incidentally, in this second example embodiment, the ECU has a structure that corresponds to the required driving force calculating portion.

[0043] The control apparatus for a vehicle in this second example embodiment described above is able to display the following effects, in addition to the effects described in (1) above.

(3) In this second example embodiment, when calculating the required driving force T_{dc} of the vehicle based on the accelerator operation amount $Acc\theta$ during

execution of gear rattle noise suppression control, the electronic control unit ECU calculates the required driving force T_{dc} to be smaller by the amount of the decrease in the engine torque that occurs when that gear rattle noise suppression control is executed. Therefore, according to this example embodiment, the estimated required driving force of the vehicle is able to match the actual required driving force of the vehicle even though the engine output of the engine decreases as a result of the executing the gear rattle noise suppression control.

[0044] Incidentally, the example embodiment described above may also be modified as described below.

In the second example embodiment, when gear rattle noise suppression control is executed, the electronic control unit ECU calculates the required driving force T_{dc} to be smaller by the amount of the decrease in the engine torque that occurs when that gear rattle noise suppression control is executed. However, this calculation may also be omitted if the deviation between the required driving force of the vehicle estimated from the accelerator operation amount $Acc\theta$ when the gear rattle noise suppression control is being executed and the actual required driving force of the vehicle is negligible.

[0045] In the example embodiments described above, the second electric motor MG2 that is directly connected to the output shaft OS of the transaxle is provided, and the gear rattle noise suppression control is executed when the torque generated by this second electric motor MG2 is close to zero. However, when rattle noise of the gears in the transaxle is also likely to occur at other times, the gear rattle noise suppression control may be executed at times other than when the torque generated by the second electric motor MG2 is close to zero. In this case as well, if the operating point of the engine ENG is changed so that the engine output decreases when gear rattle noise suppression control is executed, or to the side where the engine output decreases with respect to the constant power line of the engine ENG immediately before the gear rattle noise suppression control is executed, gear rattle noise in the transaxle can be suppressed while inhibiting a decrease in fuel efficiency.

[0046] In the example embodiments described above, the invention is applied to

a hybrid vehicle that has the engine ENG and two electric motors MG1 and MG2 as driving sources, and two planetary gear sets P1 and P2 in the transaxle. However, the invention may also similarly be applied to a vehicle that has a drive system of another structure, including a non-hybrid vehicle.

CLAIMS:

1. A control apparatus for a vehicle, that executes gear rattle noise suppression control that suppresses gear rattle noise of gears provided in a transaxle by increasing engine speed, characterized in that:

the control apparatus decreases engine output when executing the gear rattle noise suppression control.

2. The control apparatus according to claim 1, wherein the control apparatus changes an operating point of an engine such that the engine speed increases and the engine output decreases, when executing the gear rattle noise suppression control.

3. The control apparatus according to claim 2, wherein when executing the gear rattle noise suppression control, the control apparatus changes the operating point such that the engine output decreases with respect to a constant power line of the engine immediately before the gear rattle noise suppression control is executed.

4. The control apparatus according to any one of claims 1 to 3, wherein the vehicle is a hybrid vehicle provided with the engine and an electric motor as driving sources, and the control apparatus compensates for a decrease in engine torque that occurs when the gear rattle noise suppression control is executed by increasing the torque of the electric motor.

5. The control apparatus according to any one of claims 1 to 3, further comprising:
a required driving force calculating portion that calculates a required driving force of the vehicle based on an accelerator operation amount,

wherein when the gear rattle noise suppression control is executed, the required driving force calculating portion calculates the required driving force to be smaller according to the decrease in the engine torque that occurs when the gear rattle noise

suppression control is executed.

6. The control apparatus according to any one of claims 1 to 5, wherein the vehicle is provided with an electric motor that is directly connected to an output shaft of the transaxle, and the gear rattle noise suppression control is executed when the torque of the electric motor becomes equal to or less than a predetermined value.

7. The control apparatus according to claim 6, wherein the predetermined value is close to zero.

8. A control apparatus for a vehicle, comprising:

a control portion that executes gear rattle noise suppression control that suppresses gear rattle noise of gears provided in a transaxle by increasing engine speed,
wherein the control portion decreases engine output when executing the gear rattle noise suppression control.

9. A control method for a vehicle, comprising:

executing gear rattle noise suppression control that suppresses gear rattle noise of gears provided in a transaxle by increasing engine speed; and
decreasing engine output when executing the gear rattle noise suppression control.

10. The control method according to claim 9, wherein an operating point of an engine is changed such that the engine speed increases and the engine output decreases, when the gear rattle noise suppression control is executed.

11. The control method according to claim 10, wherein when the gear rattle noise suppression control is executed, the operating point is changed such that the engine output decreases with respect to a constant power line of the engine immediately before the gear rattle noise suppression control is executed.

12. The control method according to any one of claims 9 to 11, wherein the vehicle is a hybrid vehicle provided with the engine and an electric motor as driving sources, and a decrease in engine torque that occurs when the gear rattle noise suppression control is executed is compensated for by increasing the torque of the electric motor.

13. The control method according to any one of claims 9 to 11, further comprising:
calculating a required driving force of the vehicle based on an accelerator operation amount,

wherein when the gear rattle noise suppression control is executed, the required driving force is calculated to be smaller according to a decrease in an engine torque value that occurs when the gear rattle noise suppression control is executed.

14. The control method according to any one of claims 9 to 13, wherein the vehicle is provided with an electric motor that is directly connected to an output shaft of the transaxle, and the gear rattle noise suppression control is executed when the torque of the electric motor becomes equal to or less than a predetermined value.

15. The control method according to claim 14, wherein the predetermined value is close to zero.

FIG. 2

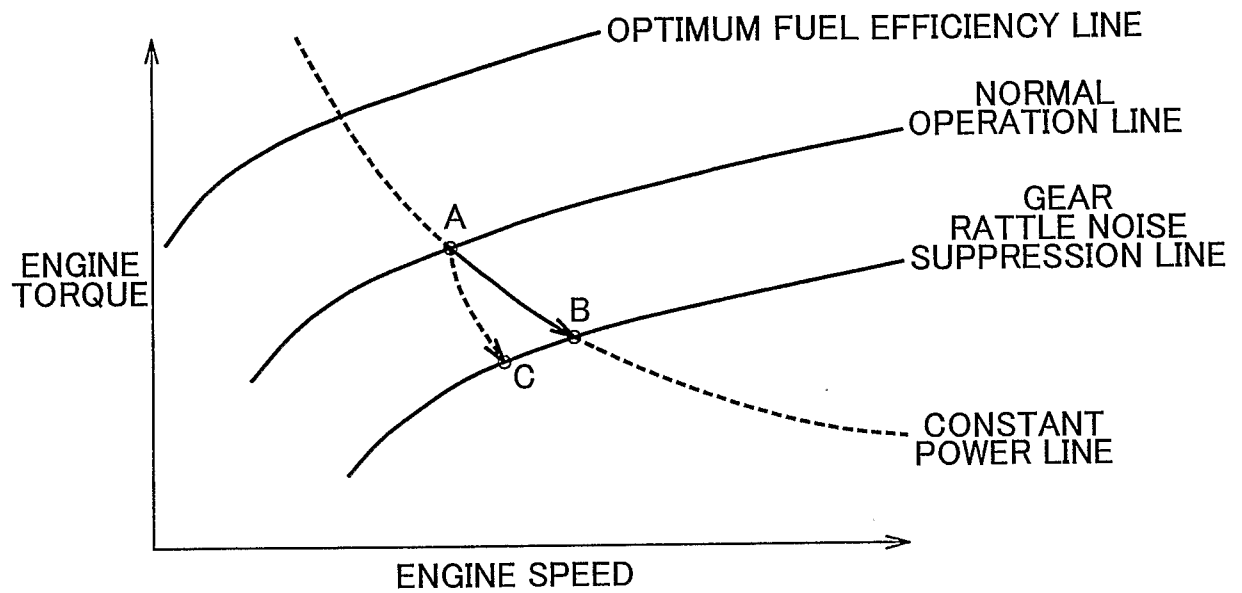


FIG. 3

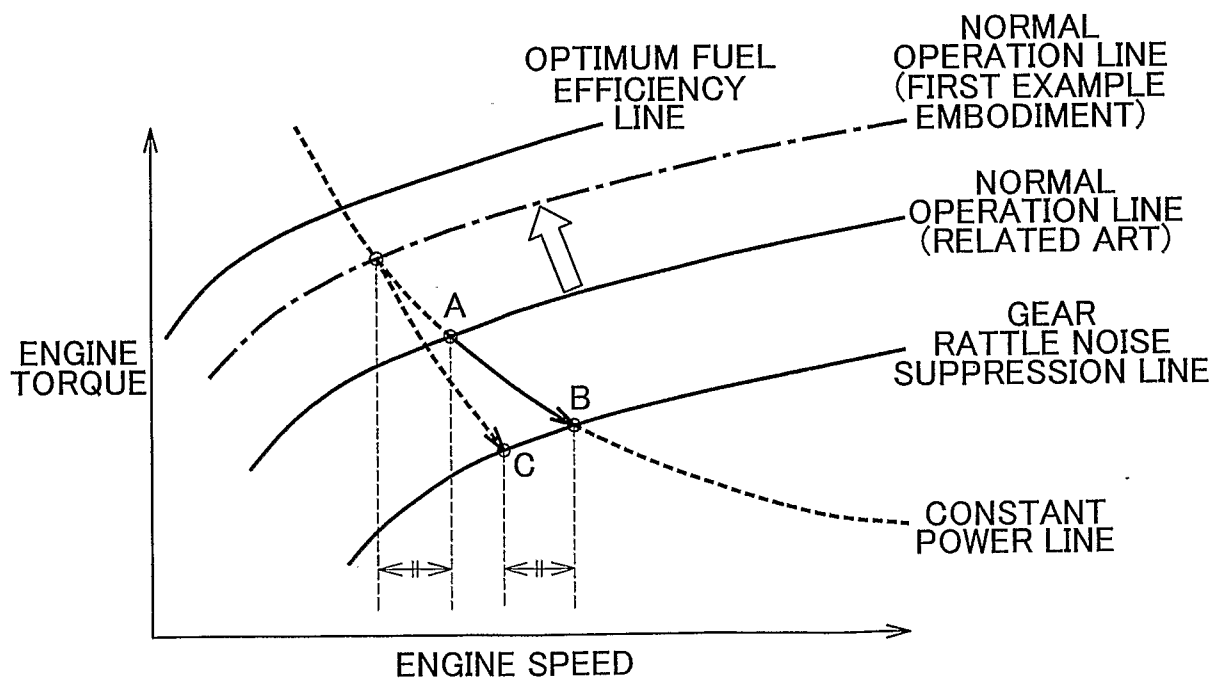


FIG. 4

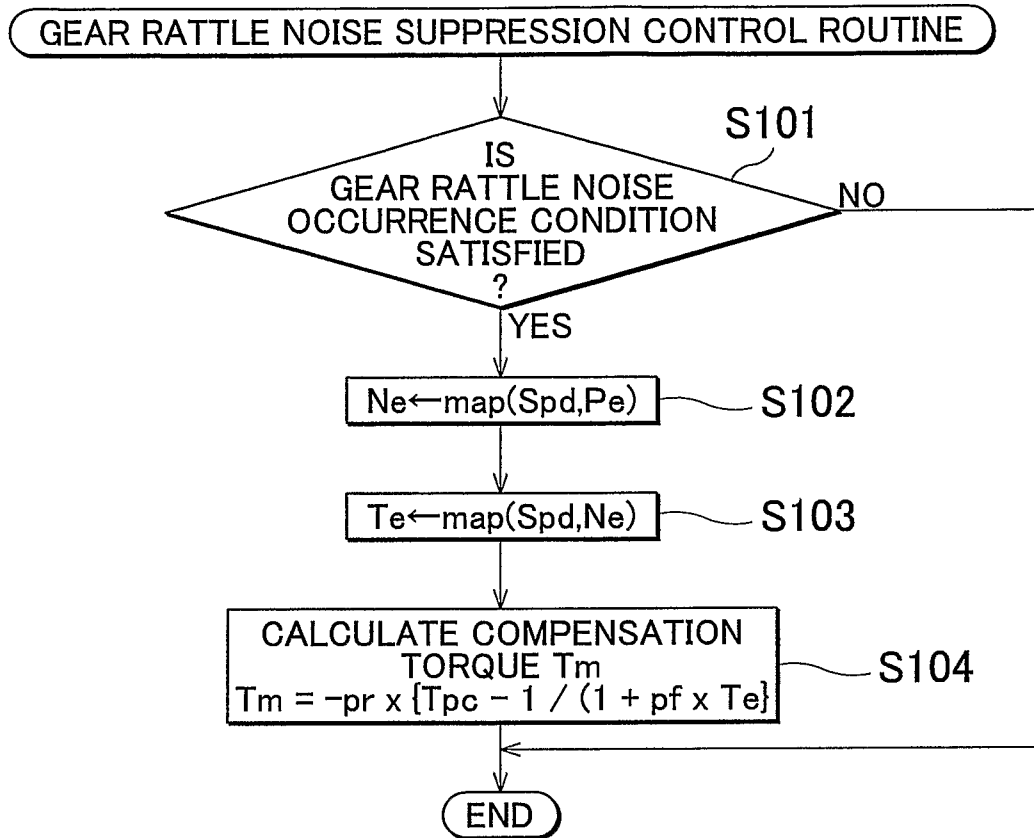


FIG. 5

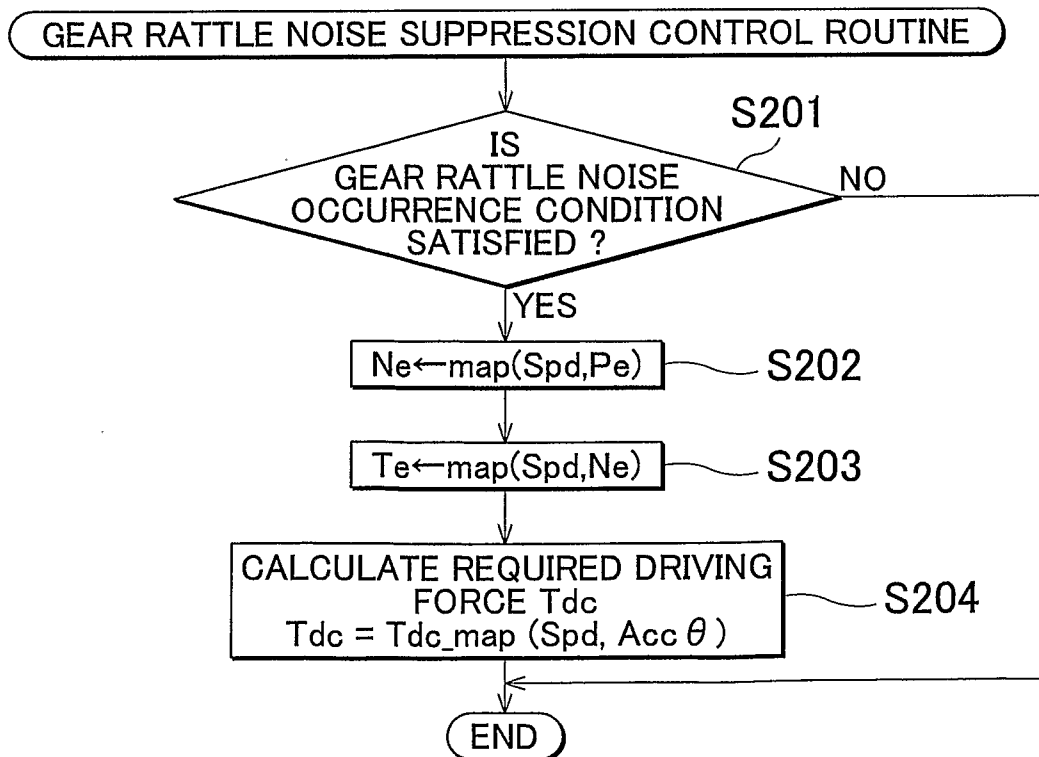
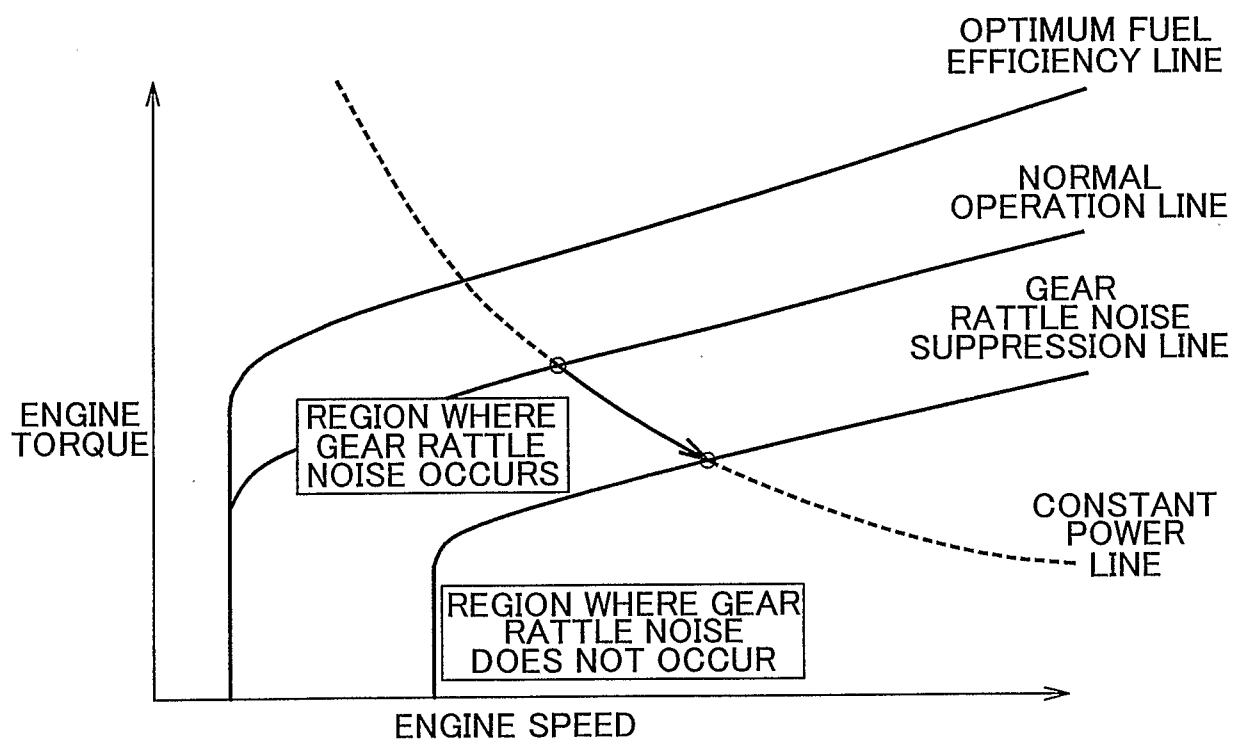


FIG. 6



INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2010/000860

A. CLASSIFICATION OF SUBJECT MATTER

INV. B60W20/00 B60K6/365 B60K6/445 B60K6/547 F16H57/00
ADD. B60W10/06 B60W10/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B60W B60K F16H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 916 539 A2 (TOYOTA MOTOR CO LTD [JP]) 19 May 1999 (1999-05-19) * abstract paragraph [0010] - paragraph [0012] paragraph [0017] - paragraph [0019] paragraph [0066] - paragraph [0066] paragraph [0075] - paragraph [0076] paragraph [0081] - paragraph [0081] paragraph [0087] - paragraph [0087] figures 1,3-5,9-12 ----- -/--	1-15

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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- * & * document member of the same patent family

Date of the actual completion of the international search

22 September 2010

Date of mailing of the international search report

06/10/2010

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INTERNATIONAL SEARCH REPORT

International application No

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2006/109379 A1 (TOYOTA MOTOR CO LTD [JP]; SHIMIZU YASUO [JP]; WATANABE HIDETO [JP]) 19 October 2006 (2006-10-19) * abstract paragraph [0041] - paragraph [0043] paragraph [0045] - paragraph [0045] claims 1-3,10,11 figures 1,2,7,8 -----	1-15
X	US 5 967 940 A (YAMAGUCHI KATSUHIKO [JP]) 19 October 1999 (1999-10-19) cited in the application * abstract claims 1-3,7-9,12,14-18 figures 1-3,8-20 -----	1-15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2010/000860

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