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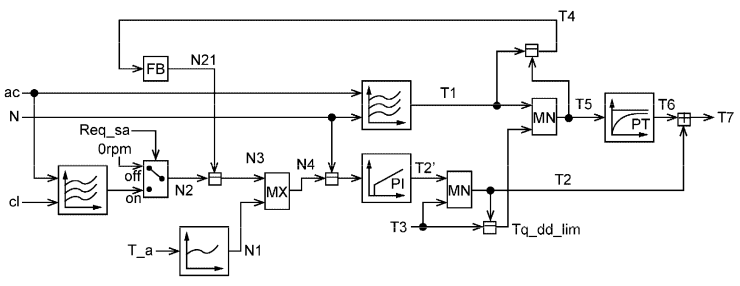
(54) CONTROL DEVICE FOR INTERNAL COMBUSTION ENGINE

(57) [Problem] The present invention provides a controller for an internal combustion engine capable of suppressing worsening of ride comfort at starting of a vehicle.

[Means for Resolution] The controller for the internal combustion engine sets a start-time target engine speed of the internal combustion engine on the basis of a basic start-time target engine speed corresponding to an accelerator operation amount by a driver in a period until a vehicle speed reaches a specified cancellation threshold value when detecting a starting operation of the vehicle, sets idle rotation control torque of the internal combustion engine on the basis of a value of higher one of a target idle engine speed and the start-time target engine speed of the internal combustion engine, sets driver request torque of the internal combustion engine on the basis of basic driver request torque corresponding to the accelerator operation amount by the driver such that a change speed does not exceed a specified threshold value, adds the idle rotation control torque to the driver request torque so as to set target torque with specified upper limit torque as an upper limit, and, when a sum of the idle rotation control torque and the basic driver request torque exceeds the upper limit torque at the time of controlling the internal combustion engine on the basis of the target torque, sets the idle rotation control torque, from which at least differential torque between the sum and the upper limit torque is subtracted.

[FIG. 2]



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Description

Technical Field

[0001] The present invention relates to a controller for an internal combustion engine.

Background Art

[0002] A controller that assists with starting of a vehicle and prevents an internal combustion engine from being stopped has been known. For example, a start assistance system is disclosed in PTL 1. The start assistance system assists with starting of a vehicle on an uphill road or of a loaded vehicle. In a period from disengaging a clutch to riding the clutch, the start assistance system increases a target engine speed with respect to an accelerator pedal depression amount at the starting of the vehicle on the uphill road or of the loaded vehicle to be higher than that at the starting of the vehicle on a flat load or of an unloaded vehicle.

[0003] Conventionally, as control for the internal combustion engine mounted to the vehicle, torque control has been known to calculate torque by using the torque as an operation parameter. As the torque control for the internal combustion engine, idle rotation torque control and driver request torque control are available. In the idle rotation torque control, an engine speed of the internal combustion engine during idle operation is maintained at a specified engine speed. In the driver request torque control, an increase/reduction of the request torque caused by a driver's accelerator operation is reflected to behavior of the internal combustion engine. Of these, in the driver request torque control, in order to alleviate a shock at the time of depressing the accelerator pedal, such processing is executed to limit a change speed during the increase in the driver request torque (hereinafter also referred to as "damping processing"). Meanwhile, in the idle rotation torque control, the damping processing is not executed so as not to impose an adverse effect thereof on maintaining a target idle engine speed.

[0004] As a method for calculating target torque that is a final torque target value for controlling the internal combustion engine, a method for adding idle rotation control torque and the driver request torque is available. The method for adding two types of the request torque has an advantage of favorable responsiveness at the time of depressing the accelerator pedal in an idle operation state.

[0005] In addition, as a method for controlling the internal combustion engine at the starting of the vehicle, control for limiting a maximum value of the target torque (maximum torque) to be equal to or lower than upper limit torque is also used. The upper limit torque in this case is set in consideration of mechanical strength of the internal combustion engine, a smoke generation range thereof, and the like. In this control for limiting the maximum torque, in order to bring a sum of the idle rotation control torque and the driver request torque to be equal to or lower than the upper limit torque, a magnitude of torque that is acquired by subtracting the upper limit torque from the sum of the torque is subtracted from the driver request torque in advance. In order to reliably bring the driver request torque after the damping processing to be equal to or lower than the upper limit torque, the subtracted value equals the driver request torque prior to the damping processing.

Citation List

Patent Literature

[0006] PTL 1: JP-A-2016-200093

Summary of Invention

Technical Problem

[0007] Here, in order to improve startability at the starting of the vehicle, when the vehicle start operation is detected on the basis of states of the clutch and gears, the following control is possibly executed in a period until a vehicle speed reaches a specified threshold value. In the control, the target engine speed, which is used to calculate the idle rotation control torque, is increased on the basis of an accelerator operation amount and a clutch position. When such control is executed, it is considered that the idle rotation control torque is increased and the idle rotation control torque reaches the upper limit torque. As described above, in the control for subtracting a surplus of the torque exceeding the upper limit torque from the driver request torque, the driver request torque is limited to zero when the idle rotation control torque reaches the upper limit torque. However, since the idle rotation control torque equals the upper limit torque, the target torque that is calculated by adding the idle rotation control torque and the driver request torque also equals the upper limit torque.

[0008] Then, when the vehicle speed exceeds the specified threshold value and increasing the target engine speed to calculate the idle rotation control torque is canceled, the idle rotation control torque becomes zero, and the driver request torque is no longer limited to zero. Consequently, the value of the driver request torque after the damping processing is gradually increased from zero. For this reason, the target torque, which is acquired by adding the idle rotation control torque and the driver request torque, is temporarily dropped from the upper limit torque, which possibly worsens ride comfort.

[0009] The present invention has been made in view of the above problem and therefore has a purpose of providing a controller for an internal combustion engine capable of suppressing worsening of ride comfort at starting of a vehicle.

Solution to Problem

[0010] According to an aspect of the present invention, a controller for an internal combustion engine is provided. The controller includes: a start-time target engine speed setting section that, when detecting a starting operation of a vehicle, sets a start-time target engine speed of the internal combustion engine on the basis of a basic start-time target engine speed corresponding to an accelerator operation amount by a driver in a period until a vehicle speed reaches a specified cancellation threshold value; an idle rotation control torque calculation section that sets idle rotation control torque of the internal combustion engine on the basis of a value of higher one of a target idle engine speed and the start-time target engine speed of the internal combustion engine; a driver request torque calculation section that sets driver request torque of the internal combustion engine on the basis of basic driver request torque corresponding to the accelerator operation amount by the driver such that a change speed does not exceed a specified threshold value; a target torque calculation section that adds the idle rotation control torque and the driver request torque and sets target torque with specified upper limit torque as an upper limit; and an engine control section that controls the internal combustion engine on the basis of the target torque. In the case where a sum of the idle rotation control torque and the basic driver request torque exceeds the upper limit torque, the idle rotation control torque setting section sets the idle rotation control torque, from which at least differential torque between the sum and the upper limit torque is subtracted.

Advantageous Effects of Invention

[0011] As it has been described so far, according to the present invention, it is possible to suppress worsening of ride comfort at starting of the vehicle.

Brief Description of Drawings

[0012]

Fig. 1 is a schematic view illustrating a configuration example of a controller for an internal combustion engine according to an embodiment of the present invention.

Fig. 2 is an explanatory view illustrating a control logic of torque control that is executed by the controller according to the embodiment.

Fig. 3 is a flowchart of the torque control by the controller according to the embodiment.

Fig. 4 is an explanatory view illustrating a control logic of torque control according to a reference example.

Fig. 5 is an explanatory chart illustrating transition of target torque by a controller according to the reference example.

Fig. 6 is an explanatory chart illustrating transition of target torque by the controller according to the embodiment.

Description of Embodiments

[0013] A detailed description will hereinafter be made on a preferred embodiment of the present invention with reference to the accompanying drawings. In the present specification and the drawings, components that have substantially the same functional configuration will be denoted by the same reference sign, and a description thereon will not be repeated.

<1. Configuration Example of Controller for Internal Combustion Engine>

[0014] First, a description will be made on a configuration example of a controller for an internal combustion engine according to this embodiment. Fig. 1 is a schematic view illustrating a configuration example of a controller 50 for the internal combustion engine.

[0015] The controller 50 controls driving of an internal combustion engine 10 exemplified as a gasoline engine or a diesel engine. A description will hereinafter be made on a case where the internal combustion engine 10 is the diesel engine as an example.

[0016] The internal combustion engine 10 includes plural cylinders, and a piston reciprocates in each of the cylinders. The piston reciprocates once every time a crankshaft makes one rotation in conjunction with the rotation of the crankshaft. The internal combustion engine 10 includes a fuel injector corresponding to each of the cylinders. The fuel injector primarily injects fuel in an intake stroke and generates air-fuel mixture in the cylinder. The generated air-fuel mixture is ignited spontaneously in a compression stroke, is expanded, and causes the crankshaft to rotate. The controller 50 controls driving of the fuel injector. Power of the internal combustion engine 10 is transmitted to a transmission 21 via the crankshaft. The transmission 21 includes a stepped or stepless transmission mechanism, changes a rotational frequency of the crankshaft at a specified gear ratio, and transmits the changed rotational frequency to drive wheels.

[0017] The internal combustion engine 10 includes a crank angle sensor 15 that detects a rotation angle of the crankshaft. A sensor signal of the crank angle sensor 15 is input to the controller 50. Based on the input sensor signal, the controller 50 detects the rotational frequency of the crankshaft, that is, a speed of the internal combustion engine. The transmission 21 includes a vehicle speed sensor 17 that detects a vehicle speed. A sensor signal of the vehicle speed sensor 17 is input to the controller 50. Based on the input sensor signal, the controller 50 detects the vehicle speed.

[0018] The controller 50 is partially or entirely constructed of a microcomputer, a microprocessor, or the like, for example. Alternatively, the controller 50 may par-

tially or entirely be constructed of one whose firmware and the like can be updated, or may partially or entirely be a program module or the like that is executed by a command from a central processing unit (CPU) or the like, for example.

[0019] Fig. 1 illustrates a functional configuration of the controller 50. The controller 50 includes a start-time target engine speed setting section 51, an idle rotation control torque calculation section 53, a driver request torque calculation section 55, a target torque calculation section 57, and an engine control section 59. More specifically, each of these sections may be a function that is implemented when the microcomputer or the like executes a program.

[0020] In addition to the above, the controller 50 includes one or plural communication interfaces and drive circuits. Furthermore, the controller 50 includes a storage section, which is not illustrated, such as read only memory (ROM) and random access memory (RAM). The storage section stores the program that is executed by the microcomputer or the like, various parameters used for arithmetic processing, acquired information, arithmetic results, and the like.

[0021] As described above, the controller 50 can acquire the sensor signals of the crank angle sensor 15 and the vehicle speed sensor 17. The controller 50 can also acquire information on an operation amount of a brake pedal (hereinafter also referred to as a "brake operation amount") br, a position of a shift lever (hereinafter also referred to as a "shift position") ge, an operation amount of a clutch pedal (hereinafter also referred to as a "clutch operation amount") cl, and an operation amount of an accelerator pedal (hereinafter also referred to as an "accelerator operation amount") ac. For example, these types of the information can be acquired on the basis of sensor signals of a brake pedal sensor 31, a shift position sensor 33, a clutch pedal sensor 35, and an accelerator pedal sensor 37.

[0022] When detecting a vehicle starting operation, the start-time target engine speed setting section 51 sets a start-time target engine speed N3 of the internal combustion engine 10 in a period until a vehicle speed V reaches a specified cancellation threshold value V0, which is set in advance. In this embodiment, the start-time target engine speed setting section 51 sets the start-time target engine speed N3 on the basis of a basic start-time target engine speed N2 and a surplus engine speed N21.

[0023] The basic start-time target engine speed N2 is a target value of the engine speed that is set on the basis of the accelerator operation amount ac and the clutch operation amount cl in the case where the vehicle is set in a starting control mode. In order to improve startability at the time when the vehicle starting operation is performed and then the accelerator pedal is depressed, the start-time target engine speed setting section 51 is configured to increase the basic start-time target engine speed N2 on the basis of the accelerator operation amount ac and the clutch operation amount cl. For example, the start-time target engine speed setting section 51 increases the basic start-time target engine speed N2 as the accelerator operation amount ac is increased and as the clutch operation amount cl is reduced.

[0024] The start-time target engine speed setting section 51 sets the starting control mode to be on on the basis of the brake operation amount br, the shift position ge, and the clutch operation amount cl, for example. More specifically, in the case where the shift position ge is in a gear-in state while the clutch is disengaged, and the brake pedal is released from being depressed, the start-time target engine speed setting section 51 detects that the vehicle starting operation is about to be performed, and sets the starting control mode to be on.

[0025] Then, after setting of the starting control mode to be on, when the vehicle speed V reaches the specified cancellation threshold value V0, when the brake pedal is depressed, or the like, the start-time target engine speed setting section 51 sets the starting control mode to be off. The cancellation threshold value V0 at which the starting control mode is set to be off is a threshold value used to determine that the vehicle in a stopped state reaches a specified vehicle speed and the vehicle starting operation is thus completed.

[0026] The surplus engine speed N21 is the surplus engine speed N21 that corresponds to differential torque T4 at the time when a sum T1 + T2 of idle rotation control torque T2 and basic driver request torque T1 exceeds specified upper limit torque T3. The differential torque T4 is acquired by subtracting the upper limit torque T3 from the sum T1 + T2 of the torque. That is, the surplus engine speed N21 is an engine speed to be reduced in order to limit the sum of the output torque (T2) and the output torque (T1) to be equal to or lower than the upper limit torque T3. The output torque (T2) is torque in a case where the internal combustion engine 10 is driven at the start-time target engine speed N3 without any limitation. The output torque (T1) is torque in a case where the internal combustion engine 10 is driven on the basis of the accelerator operation amount ac without any limitation. The start-time target engine speed setting section 51 sets, as the start-time target engine speed N3, a value that is acquired by subtracting the surplus engine speed N21 from the basic start-time target engine speed N2.

[0027] The idle rotation control torque calculation section 53 sets the idle rotation control torque T2 of the internal combustion engine 10 on the basis of a value N4 of higher one of a target idle engine speed N1 and the start-time target engine speed N3 of the internal combustion engine 10. The target idle engine speed N1 is a target value of the engine speed in an idle state of the internal combustion engine 10. For example, the target idle engine speed N1 is set in advance according to an ambient temperature T_a, and is stored in the storage section. The idle rotation control torque calculation section 53 calculates the target idle engine speed N1 on the basis of the ambient temperature T_a that is detected on

the basis of a sensor signal of an ambient temperature sensor or the like.

[0028] The idle rotation control torque calculation section 53 performs a proportional-integral (PI) operation such that a difference acquired by subtracting a current engine speed N of the internal combustion engine 10 from the value N4 of the higher one of the above converges to zero, and thereby calculates the idle rotation control torque T2. In this embodiment, in order to prevent target torque T7 from finally exceeding the upper limit torque T3, the idle rotation control torque calculation section 53 sets, as the idle rotation control torque T2, a value of lower one of the basic idle rotation control torque T2', which is acquired by performing the PI operation, and the upper limit torque T3.

[0029] Based on the basic driver request torque T1 that corresponds to the accelerator operation amount ac, the driver request torque calculation section 55 sets driver request torque T6 of the internal combustion engine 10 such that a change speed does not exceed a specified threshold value. That is, the driver request torque calculation section 55 executes damping processing at the time of setting the driver request torque T6. The damping processing may be executed on the basis of a lowpass filter, for example. In this way, a shock at the time of depressing the accelerator pedal can be alleviated. However, it is preferred that the driver request torque calculation section 55 does not execute the damping processing when the driver request torque is reduced. This is to avoid timing to reduce the vehicle drive torque from being delayed.

[0030] In the case where the basic driver request torque T1 is higher than a value (T3 - T2) of remaining torque that is acquired by subtracting the idle rotation control torque T2 from the upper limit torque T3, the driver request torque calculation section 55 sets the driver request torque T6 on the basis of the value (T3 - T2) of the remaining torque such that the final target torque T7 does not exceed the upper limit torque T3. It is possible to reliably prevent the final target torque T7 from exceeding the upper limit torque T3 by using the value (T3 - T2) of the remaining torque as an input value prior to the damping processing.

[0031] The target torque calculation section 57 sets the target torque T7 by adding the idle rotation control torque T2, which is calculated by the idle rotation control torque calculation section 53, and the driver request torque T6, which is calculated by the driver request torque calculation section 55. Since the calculated target torque T7 is set with the upper limit torque T3 as an upper limit, the shock caused by depressing the accelerator pedal at the starting of the vehicle is alleviated.

[0032] The engine control section 59 controls the internal combustion engine 10 on the basis of the target torque T7, which is set by the target torque calculation section 57. More specifically, the engine control section 59 causes the internal combustion engine 10 to output torque that corresponds to the target torque T7 by controlling a fuel injection amount, fuel injection timing, an air-fuel ratio, and the like of the internal combustion engine 10.

<2. Operation of Controller>

[0033] The description has been made so far on the configuration example of the controller 50 for the internal combustion engine according to this embodiment. A description will hereinafter be made on an operation example of the controller 50 for the internal combustion engine according to this embodiment.

[0034] Fig. 2 is an explanatory view illustrating a control logic of torque control that is executed by the controller 50. A description will firstly be made on an arithmetic logic of the idle rotation control torque T2. First, the basic start-time target engine speed N2, which is calculated on the basis of the accelerator operation amount ac and the clutch operation amount cl, is calculated. In the case where the starting operation is detected in the stopped state of the vehicle and a starting control mode Req_sa is set to be on, the above basic start-time target engine speed N2 is set as the basic start-time target engine speed N2 as is. On the other hand, in the case where the starting control mode Req_sa is set to be off, the basic start-time target engine speed N2 is set to zero.

[0035] Next, the surplus engine speed N21 is subtracted from the basic start-time target engine speed N2 to calculate the start-time target engine speed N3. As described above, the surplus engine speed N21 is the engine speed that should be subtracted in order to limit the final target torque T7 to be equal to or lower than the upper limit torque T3. Next, the target idle engine speed N1, which is set according to the ambient temperature T_a, is compared to the calculated start-time target engine speed N3. Then, the PI operation is performed such that the difference acquired by subtracting the current engine speed N of the internal combustion engine 10 from the value N4 of the higher one of the above converges to zero. Consequently, basic idle rotation control torque T2' is calculated.

[0036] Then, a value of lower one of the basic idle rotation control torque T2' and the upper limit torque T3 is set as the idle rotation control torque T2 such that the final target torque T7 does not exceed the upper limit torque T3, which is set in advance.

[0037] Here, the surplus engine speed N21 is calculated by subjecting the differential torque T4 to a feedback operation, and the differential torque T4 is acquired by subtracting a value T5 of lower one of the value (T3 - T2), which is acquired by subtracting the idle rotation control torque T2 from the upper limit torque T3, and the basic driver request torque T1, which is calculated on the basis of the accelerator operation amount ac and the engine speed N of the internal combustion engine 10, from the basic driver request torque T1.

[0038] A description will be made on an arithmetic logic of the driver request torque T6. First, the basic driver

request torque T1 is calculated on the basis of the accelerator operation amount ac and the engine speed N of the internal combustion engine 10. Next, the basic driver request torque T1 is compared to the value (T3 - T2), which is acquired by subtracting the idle rotation control torque T2 limited by the upper limit torque T3, such that a sum of the driver request torque and the idle rotation control torque falls within the upper limit torque (T3), and the value T5 of the lower one thereof is subjected to the damping processing. In this way, the driver request torque T6 is calculated.

[0039] The idle rotation control torque T2 and the driver request torque T6, which are calculated just as described, are added, and the final target torque T7 is thereby calculated. That is, the controller 50 according to this embodiment limits the idle rotation control torque T2 instead of the driver request torque T6 in order to limit the final target torque T7 to be equal to or lower than the upper limit torque T3. In addition, the controller 50 executes, in advance, the subtraction processing of the start-time target engine speed N4, which is used to calculate the idle rotation control torque T2, instead of calculating the idle rotation control torque T2 and the driver request torque T6, adding these to calculate the target torque T7, and thereafter, executing subtraction processing to suppress the target torque T7 to the upper limit torque T3. In this way, it is possible to suppress the timing to reduce the torque output from the internal combustion engine 10 from being delayed.

[0040] Fig. 3 is a flowchart of the torque control that is executed by the controller 50 for the internal combustion engine on the basis of the control logic illustrated in Fig. 2.

[0041] First, the driver request torque calculation section 55 calculates the basic driver request torque T1 on the basis of the accelerator operation amount ac and the engine speed N of the internal combustion engine 10 (step S11). Next, the start-time target engine speed setting section 51 sets the target idle engine speed N1 on the basis of the ambient temperature T_a (step S13). Then, the start-time target engine speed setting section 51 acquires the setting information of the starting control mode Req_sa (step S15), and determines whether the starting control mode Req_sa is set to be on (step S17).

[0042] If the starting control mode Req_sa is set to be on (S17/Yes), the start-time target engine speed setting section 51 sets the basic start-time target engine speed N2 on the basis of the accelerator operation amount ac and the clutch operation amount cl (step S19). On the other hand, if the starting control mode Req_sa is set to be off (S17/No), the start-time target engine speed setting section 51 sets the basic start-time target engine speed N2 to zero (step S21) .

[0043] Next, the driver request torque calculation section 55 calculates the upper limit torque T3 on the basis of the parameters such as the engine speed N of the internal combustion engine 10 (step S23). Then, the idle rotation control torque calculation section 53 calculates the basic idle rotation control torque T2' at the time of performing the PI operation such that the value acquired by subtracting the current engine speed N of the internal combustion engine 10 from the basic start-time target engine speed N2 converges to zero, and determines whether the sum of the basic idle rotation control torque T2' and the basic driver request torque T1 exceeds the upper limit torque T3 (step S25).

[0044] If the sum of the basic driver request torque T1 and the basic idle rotation control torque T2' exceeds the upper limit torque T3 (S25/Yes), the idle rotation control torque calculation section 53 calculates the differential torque T4 ((T1 + T2) - T3) (step S27). On the other hand, if the sum of the basic driver request torque T1 and the basic idle rotation control torque T2' does not exceed the upper limit torque T3 (S25/No), the idle rotation control torque calculation section 53 sets the differential torque T4 to zero (step S29) .

[0045] In the control logic illustrated in Fig. 2, the processing in step S25 to step S29 corresponds to a portion in which the value T5 of the lower one of the value (T3 - T2), which is acquired by subtracting the idle rotation control torque T2 (= MIN(T2', T3)) as the value of the lower one of the upper limit torque T3 and the basic idle rotation control torque T2' from the upper limit torque T3, and the basic driver request torque T1 is subtracted from the basic driver request torque T1, so as to calculate the differential torque T4.

[0046] Next, the idle rotation control torque calculation section 53 performs the feedback operation on the basis of the calculated differential torque T4, and calculates the surplus engine speed N21 (step S31). Then, the start-time target engine speed setting section 51 subtracts the surplus engine speed N21 from the basic start-time target engine speed N2, which is calculated in step S19 or S21, and sets the start-time target engine speed N3 (step S33). Next, the idle rotation control torque calculation section 53 calculates the value N4 of the higher one of the start-time target engine speed N3 and the target idle engine speed N1 (step S35).

[0047] Next, the idle rotation control torque calculation section 53 performs the PI operation such that the value acquired by subtracting the current engine speed N of the internal combustion engine 10 from the above calculated value N4 converges to zero, and updates the basic idle rotation control torque T2' (step S37). Then, the idle rotation control torque calculation section 53 compares the basic idle rotation control torque T2' to the upper limit torque T3, and calculates the value of the lower one thereof as the idle rotation control torque T2 (step S39).

[0048] Next, the driver request torque calculation section 55 compares the basic driver request torque T1 to the value (T3 - T2), which is acquired by subtracting the idle rotation control torque T2 from the upper limit torque T3, and calculates the value T5 of the lower one thereof (step S41). Then, the driver request torque calculation section 55 executes the damping processing of the above value T5 on the basis of the lowpass filter, and calculates the driver request torque T6 (step S43).

[0049] Next, the target torque calculation section 57 adds the idle rotation control torque T2, which is calculated in step S39, and the driver request torque T6, which is calculated in step S43, to set the final target torque T7 (step S45). The set target torque T7 is used as the control parameter for the engine control section 59, and the torque output from the internal combustion engine 10 is thereby controlled. The controller 50 repeatedly executes the processing in step S11 to step S45 so far, and thereby executes the torque control for the internal combustion engine 10 at the starting of the vehicle.

[0050] Just as described, the controller 50 limits the idle rotation control torque T2 instead of the driver request torque T6, and calculates the final target torque T7. As a result, at a time point at which the vehicle speed V reaches the specified cancellation threshold value V0 and the start-time target engine speed is set to zero, the idle rotation control torque T2 is avoided from reaching the upper limit torque T3, and the driver request torque T6 is thereby avoided from being limited to zero. Accordingly, along with the damping processing of the driver request torque T6, the reduction in the target torque T7 at the time of switching the starting control mode from on to off is alleviated. Therefore, worsening of ride comfort can be suppressed.

<3. Operational Effects>

[0051] Next, a description will be made on operational effects exerted by the controller 50 for the internal combustion engine according to this embodiment.

[0052] First, a description will be made on a reference example in which the target torque T7 is significantly reduced at the time of switching the starting control mode from on to off. Fig. 4 is an explanatory view illustrating a control logic of torque control according to the reference example, and Fig. 5 is an explanatory chart illustrating transition of the target torque T7 in the case where starting control is executed on the basis of the control logic.

[0053] As illustrated in Fig. 4, in the control logic according to the reference example, in the case where the sum of the basic driver request torque T1 and the idle rotation control torque T2 exceeds the upper limit torque T3, processing to subtract the surplus engine speed (N21), which corresponds to the differential torque (T4), from the basic start-time target engine speed N2 in advance is not executed.

[0054] As illustrated in Fig. 5, the brake pedal is depressed, the shift lever is in a neutral state, the clutch that connects the internal combustion engine 10 to the transmission 21 is engaged, and the accelerator pedal is released. In such a state, the idle rotation control torque T2, which is calculated on the basis of the target idle engine speed N1, is set as the target torque T7 (a period up to time ti1).

[0055] It is assumed that the clutch is disengaged at the time ti1, that the shift position is switched from the neutral state to the gear-in state at time ti2, and that the brake pedal is released at time ti3. In such a case, in order to improve responsiveness at the time of depressing the accelerator pedal, the basic start-time target engine speed N2 is set to be a higher value than the target idle engine speed N1. In conjunction therewith, the idle rotation control torque T2, which is calculated on the basis of the basic start-time target engine speed N2, is set as the target torque T7. Since the idle rotation control torque T2 is subjected to the PI operation, the idle rotation control torque T2 is gradually increased at the time ti3 onward, and the engine speed N of the internal combustion engine 10 is also gradually increased.

[0056] When the accelerator pedal is depressed at time ti4, the basic start-time target engine speed N2, which is set according to the accelerator operation amount ac, is further increased. In conjunction therewith, the idle rotation control torque T2 is increased. In addition, the basic driver request torque T1, which is set on the basis of the accelerator operation amount ac and the engine speed N of the internal combustion engine 10, is increased, and the driver request torque T6 is increased. Accordingly, the target torque T7, which is acquired by adding the idle rotation control torque T2 and the driver request torque T6, is also increased. Since the driver request torque T6 has been subjected to the damping processing, the driver request torque T6 and the target torque T7 are gradually increased.

[0057] However, in a period from the time ti4 to time ti5, the idle rotation control torque T2 does not reach the upper limit torque T3. Accordingly, while the idle rotation control torque T2 is not limited, the basic driver request torque T1 is limited by the difference (T3 - T2) between the upper limit torque T3 and the idle rotation control torque T2 such that the sum of the driver request torque and the idle rotation control torque falls within the upper limit torque T3.

[0058] At the time ti5, the clutch starts being shifted to a riding state, which further increases the basic start-time target engine speed N2. Consequently, the idle rotation control torque T2 is increased. Thus, the driver request torque T6 is reduced to limit the target torque T7 to the upper limit torque T3. Then, when the idle rotation control torque T2 reaches the upper limit torque T3 at time ti6, the driver request torque T6 is limited to zero onward.

[0059] When the vehicle speed V reaches the specified cancellation threshold value V0 in such a state at time ti7, the starting control mode is canceled, and the basic start-time target engine speed N2 is returned to zero. As a result, while the idle rotation control torque T2 becomes zero, the driver request torque T6, which is subjected to the damping processing, is gradually increased until reaching the upper limit torque T3. Since the driver request torque T6, which is subjected to the damping processing, is increased over time, the target torque T7 is significantly reduced immediately after the time ti7, at which the starting control mode is canceled.

[0060] Fig. 6 is an explanatory chart illustrating the transition of the target torque T7 in the case where the

controller 50 for the internal combustion engine 10 according to this embodiment executes the starting control.

[0061] Up to the time ti4, at which the accelerator pedal is depressed, each of the idle rotation control torque T2, the driver request torque T6, and the target torque T7 shows similar transition to that in the reference example. Here, since the idle rotation control torque T2 is subjected to the PI operation, the idle rotation control torque T2 is gradually increased at the time ti3 onward, and the engine speed N of the internal combustion engine 10 is also gradually increased.

[0062] When the accelerator pedal is depressed at the time ti4, the basic driver request torque T1, which is set on the basis of the accelerator operation amount ac and the engine speed N of the internal combustion engine 10, is increased, and the driver request torque T6 is increased. Accordingly, the target torque T7, which is acquired by adding the idle rotation control torque T2 and the driver request torque T6, is also increased. Since the driver request torque T6 has been subjected to the damping processing, the driver request torque T6 and the target torque T7 are gradually increased. Here, when the idle rotation control torque T2 is increased due to the increase in the accelerator operation amount ac, the sum of the basic driver request torque T1 and the idle rotation control torque T2 exceeds the upper limit torque T3. For this reason, the controller 50 according to this embodiment does not increase the idle rotation control torque T2.

[0063] In addition, even when the clutch starts being shifted to the riding state at the time ti5, the controller 50 according to this embodiment does not increase the idle rotation control torque T2. As a result, in the period from the time ti4 to the time ti5, the target torque T7 is lower than the upper limit torque T3, and the driver request torque T6 is set to the value acquired by subjecting the basic driver request torque T1 to the damping processing.

[0064] Thereafter, when the accelerator pedal is further depressed at time ti8, the basic driver request torque T1 is further increased. In conjunction therewith, the driver request torque T6 and the target torque T7 also start being increased. Since the clutch is brought into the riding state at the time ti8, the engine speed N of the internal combustion engine 10 is reduced once. However, due to the increase in the basic driver request torque T1, the sum of the basic driver request torque T1 and the idle rotation control torque T2 reaches the upper limit torque T3. Accordingly, at time ti9, at which the target torque T7 reaches the upper limit torque T3, onward, the driver request torque T6 is set not on the basis of the basic driver request torque T1 but on the basis of the value (T5) acquired by subtracting the idle rotation control torque T2 from the upper limit torque T3. In this way, the final target torque T7 is limited to the upper limit torque T3.

[0065] Thereafter, while the clutch is shifted from the riding state to the engaged state, the surplus engine speed N21, which corresponds to the differential torque (T4) acquired by subtracting the upper limit torque T3 from the sum (T1 + T2) of the basic driver request torque T1 and the idle rotation control torque T2, is subtracted from the basic start-time target engine speed N2, and the idle rotation control torque T2 is calculated. Accordingly, the idle rotation control torque T2 does not reach the upper limit torque T3, and the driver request torque T6 is not limited to zero. Thus, a difference between two types of the request torque is set not to be significant.

[0066] Then, when the vehicle speed V reaches the specified cancellation threshold value V0 at time ti10, the starting control mode is canceled, and the basic start-time target engine speed N2 is returned to zero. As a result, while the idle rotation control torque T2 becomes zero, the driver request torque T6, which is subjected to the damping processing, is gradually increased to the upper limit torque T3. However, in this embodiment, the idle rotation control torque T2 is limited to a lower value than the upper limit torque T3, and the driver request torque T6 is not limited to zero. Accordingly, although the driver request torque T6, which is subjected to the damping processing, is increased over time, the reduction in the target torque T7 immediately after the time ti7, at which the starting control mode is canceled, is alleviated. Thus, it is possible to suppress worsening of the ride comfort at the starting of the vehicle.

[0067] As it has been described so far, in the case where the target torque T7, which is acquired by adding the idle rotation control torque T2 and the driver request torque T6, exceeds the upper limit torque T3, at the starting of the vehicle, the controller 50 for the internal combustion engine according to this embodiment limits the start-time target engine speed N3, which is used to calculate the idle rotation control torque T2. Thus, while the idle rotation control torque T2 reaches the upper limit torque T3, it is possible to prevent the driver request torque T6 from being limited to zero. In this way, it is possible to alleviate the reduction in the target torque T7 at the time when the vehicle speed V reaches the cancellation threshold value V0 and the starting control mode is canceled. As a result, it is possible to suppress worsening of the ride comfort at the starting of the vehicle.

[0068] The detailed description has been made so far on the preferred embodiment of the present invention with reference to the accompanying drawings. However, the present invention is not limited to such an example. It is obvious that a person who has basic knowledge in the technical field to which the present invention pertains could have easily arrived at various modification examples and application examples that fall within the scope of the technical idea described in the claims. It is understood that those naturally fall within the technical scope of the present invention.

Reference Signs List

[0069]

10: Engine

50: Controller
51: Start-time target engine speed setting section
53: Idle rotation control torque calculation section
55: Driver request torque calculation section
57: Target torque calculation section
59: Engine control section

Claims

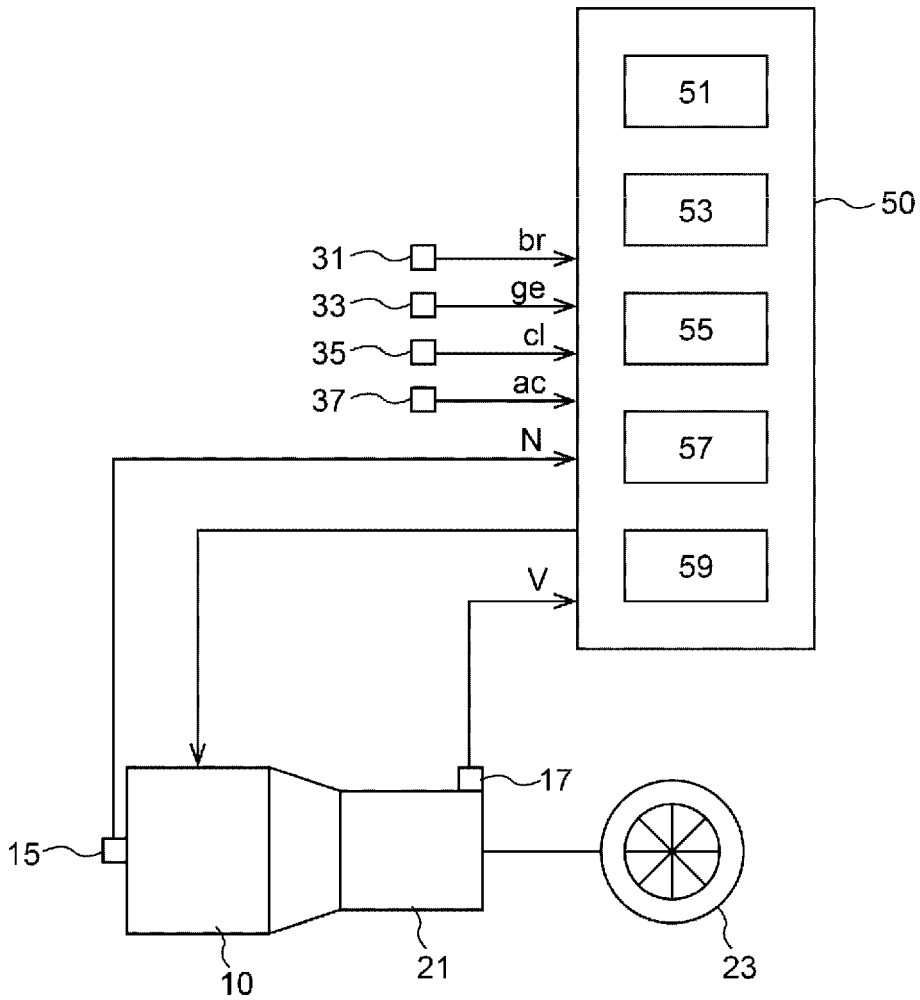
1. A controller for an internal combustion engine, the controller comprising:

a start-time target engine speed setting section (51) that, when detecting a starting operation of a vehicle, sets a start-time target engine speed (N3) of an internal combustion engine (10) on the basis of a basic start-time target engine speed (N2) corresponding to an accelerator operation amount by a driver in a period until a vehicle speed reaches a specified cancellation threshold value;
an idle rotation control torque calculation section (53) that sets idle rotation control torque (T2) of the internal combustion engine (10) on the basis of a value of higher one of a target idle engine speed (N1) and the start-time target engine speed (N3) of the internal combustion engine (10);
a driver request torque calculation section (55) that sets driver request torque (T6) of the internal combustion engine (10) on the basis of basic driver request torque (T1) corresponding to the accelerator operation amount by the driver such that a change speed does not exceed a specified threshold value;
a target torque calculation section (57) that adds the idle rotation control torque (T2) to the driver request torque (T6) and sets target torque (T7) with specified upper limit torque (T3) as an upper limit; and
an engine control section (59) that controls the internal combustion engine (10) on the basis of the target torque (T7), wherein
in the case where a sum (T2 + T1) of the idle rotation control torque (T2) and the basic driver request torque (T1) exceeds the upper limit torque (T3), the idle rotation control torque calculation section (53) sets the idle rotation control torque (T2), from which at least differential torque (T4) between the sum (T2 + T1) and the upper limit torque (T3) is subtracted.

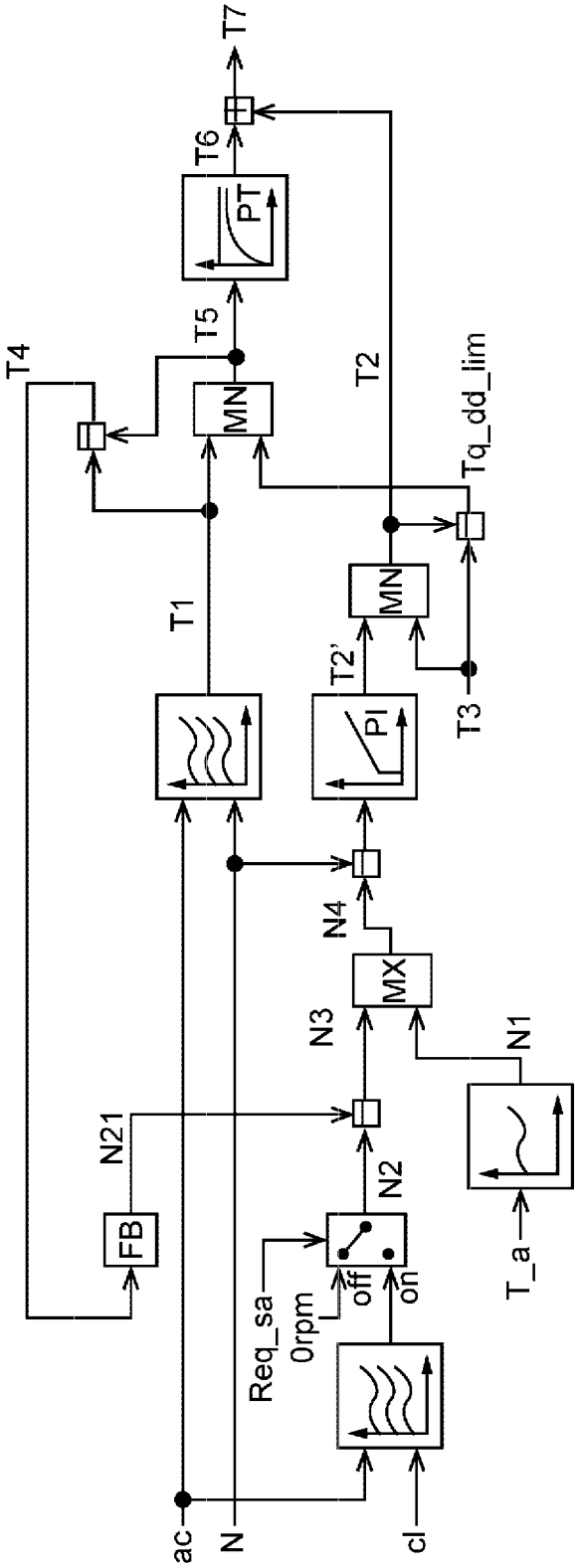
2. The controller for the internal combustion engine according to claim 1, wherein
the start-time target engine speed setting section (51) sets the start-time target engine speed (N3) by subtracting a surplus engine speed (N21) that corresponds to the differential torque (T4) from the basic start-time target engine speed (N2).

3. The controller for the internal combustion engine according to claim 1 or 2, wherein
the start-time target engine speed setting section (51) sets the basic start-time target engine speed (N2) to zero when the vehicle speed reaches the specified cancellation threshold value.

[FIG. 1]



[FIG. 2]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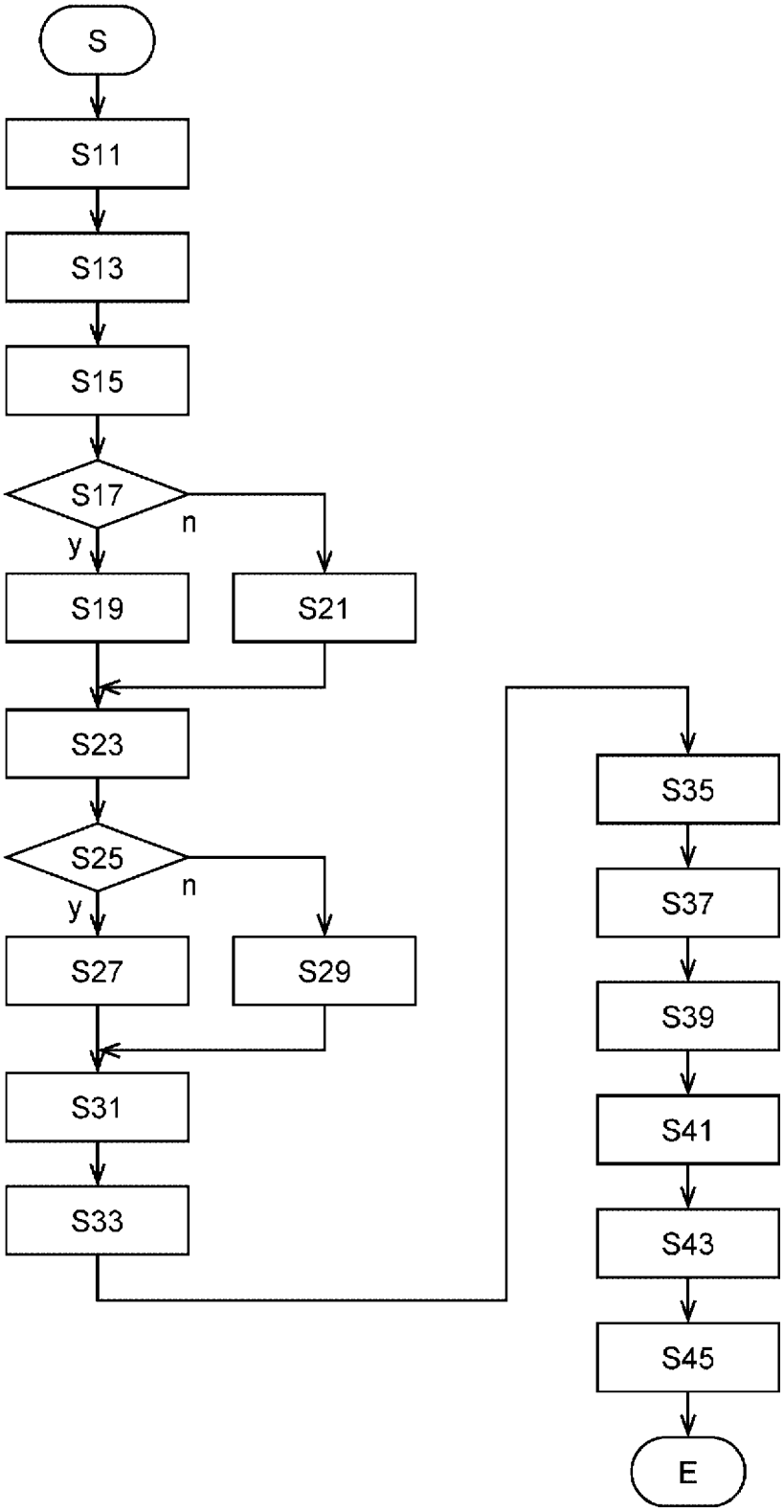
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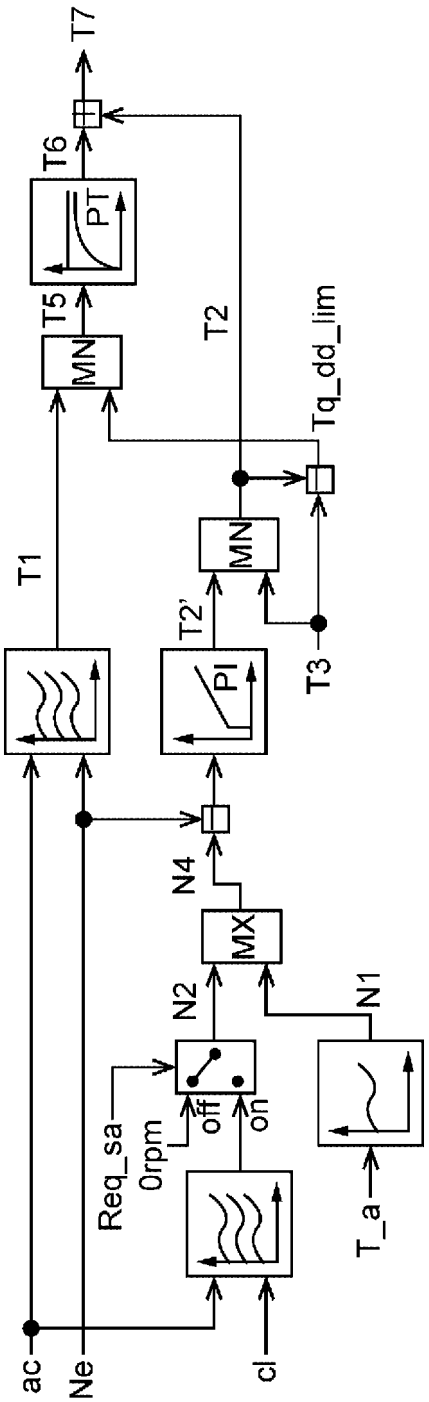
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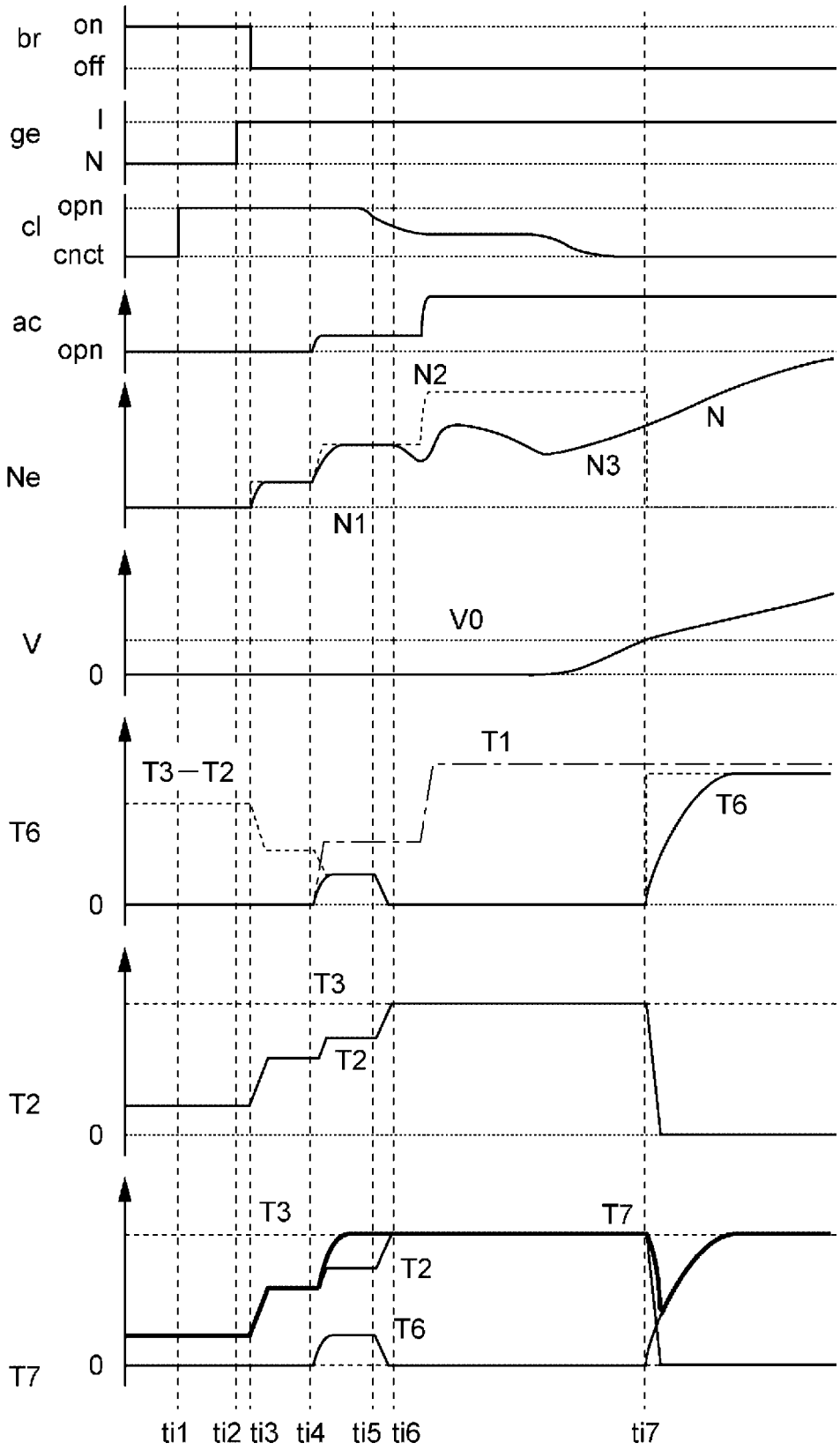
[FIG. 4]

[FIG. 5]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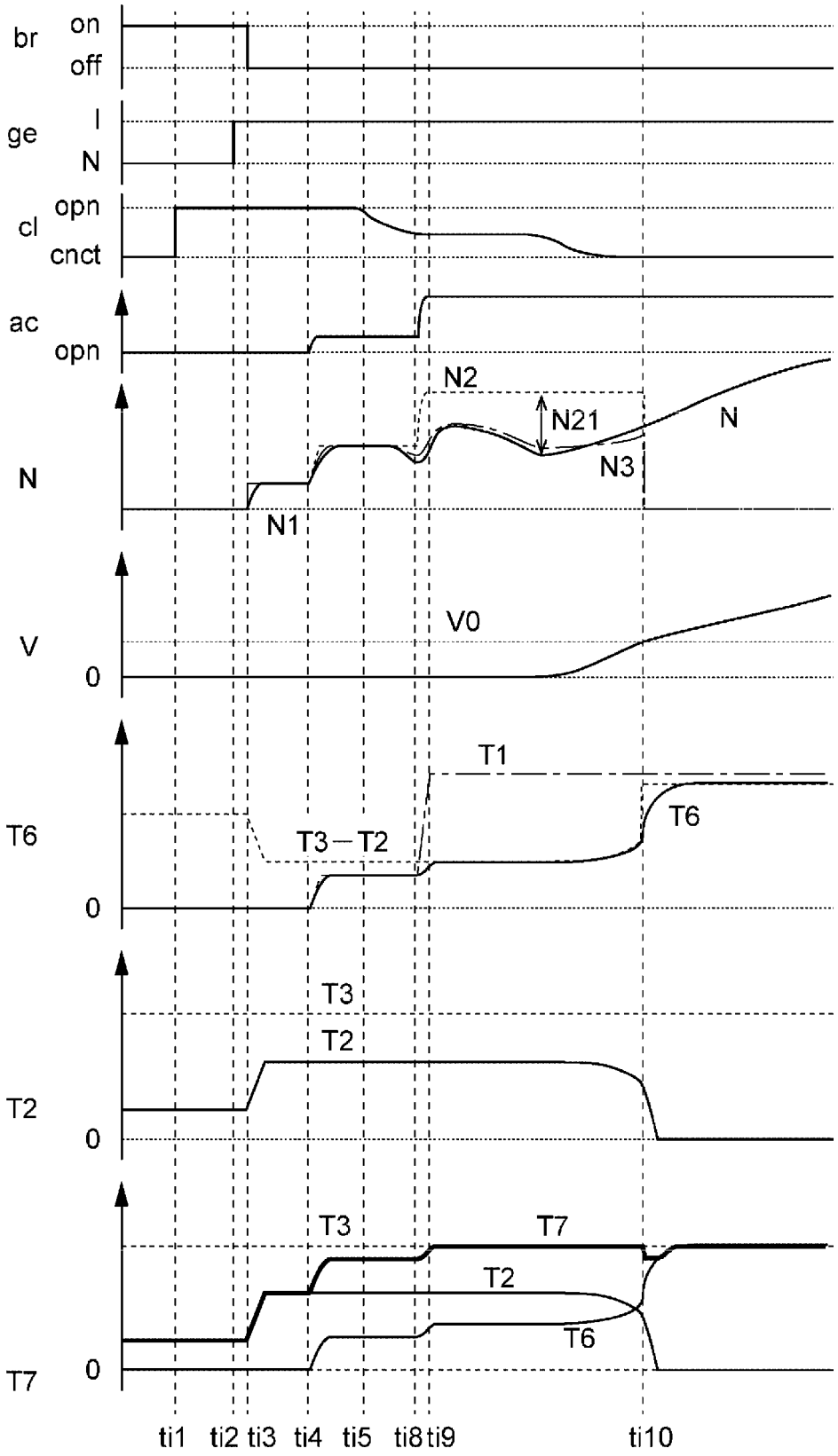
[FIG. 6]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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/035372

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. F02D29/00(2006.01)i, F02D45/00(2006.01)i
FI: F02D29/00C, F02D45/00362

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)
Int.Cl. F02D29/00, F02D45/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2020
Registered utility model specifications of Japan 1996-2020
Published registered utility model applications of Japan 1994-2020

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2000-352340 A (FUJI HEAVY IND LTD.) 19 December 2000 (2000-12-19), abstract, paragraphs [0029]-[0126], fig. 1-11	1-3
A	JP 2016-200093 A (ISUZU MOTORS LTD.) 01 December 2016 (2016-12-01), abstract, paragraphs [0010]-[0029], fig. 1-4	1-3

☐ Further documents are listed in the continuation of Box C.
☒ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 November 2020	24 November 2020

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2020/035372

JP 2000-352340 A	19 December 2000	(Family: none)	
JP 2016-200093 A	01 December 2016	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2016200093 A **[0006]**