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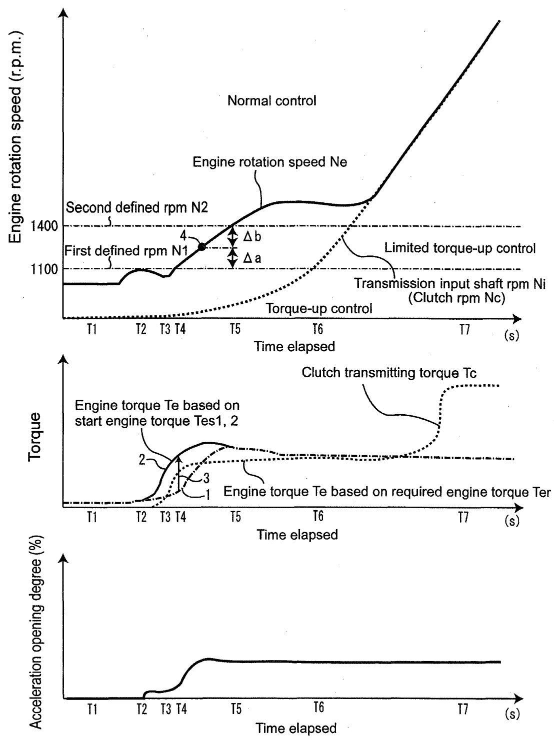
(54) VEHICULAR DRIVE APPARATUS

(57) Provided is a manual clutch-equipped vehicular drive apparatus such that engine stall can be prevented, and an appropriate engine r.p.m. can be automatically maintained. The apparatus includes a clutch sensor that acquires a clutch transmission torque being produced by a clutch; and a control unit that calculates a starting engine torque on the basis of the clutch transmission torque, and that controls an engine so as to achieve the starting engine torque when a clutch differential rotational speed is not less than a prescribed differential rotational speed and when the engine rotational speed is less than a first prescribed rotational speed.

FIG. 3



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Description

[Technical Field]

[0001] This invention relates to a vehicular drive apparatus which controls a vehicle starting operation for a vehicle equipped with a manual clutch.

[Background Art]

[0002] In an automobile which is equipped with a manual transmission (hereinafter referred to as "MT") and a manual clutch, at the start of the vehicle, an operator of the vehicle depresses the clutch pedal to be in a clutch disconnected state to shift the MT to a first speed stage. Then the operator depresses the acceleration pedal to increase the engine rotation speed and at the same time releases the clutch pedal gradually to be in a clutch connected state thereby transmitting an engine torque to vehicle wheels. Thus, the operator of the vehicle coordinates the depression operation of the acceleration pedal, in other words, an engine outputting (engine rotation speed) and the releasing operation of the clutch pedal, in other words, clutch engagement (engine load) so that a smooth vehicle start can be achieved.

[0003] In a Patent Literature 1, a technology in which an easy starting of an automobile equipped with the MT and the manual clutch can be achieved has been proposed. More specifically, according to the engine control module in the technology, the vehicle start control is executed when the shifting to the first speed stage under the vehicle speed being equal to or less than a predetermined speed is detected and the throttle opening degree is judged to be smaller than a predetermined value. In detail, the engine control module controls the engine rotation speed to a target engine rotation speed which is larger than the engine rotation speed at the engine being in idling state. Therefore, a smooth starting can be achieved without depressing the acceleration pedal.

[Citation List]

[Patent Literature]

[0004] Patent Literature 1: JP2001-263138 A

[Summary of Invention]

[Technical Problems]

[0005] However, according to the technology disclosed in the Patent Literature 1, since the engine control module controls only the engine rotation speed, the engine rotation speed control cannot be suitably operated only after the detection of drop of the engine rotation. Accordingly, for example, when the operator of the vehicle performs a sudden clutch engagement operation, an engine rotation speed increase control by the engine control module is too late to prevent drop of engine rotation speed and in the worst case, the engine may be stalled.

[0006] Further, the engine control module decides the target engine rotation speed and the engine rotation speed is controlled to be the target rotation speed. Accordingly, depending on a situation, the engine rotation speed is suddenly raised to a value which is faster than the intended speed of the operator of the vehicle. This may cause a problem that the operator may feel the operation differently from what the operator intends.

[0007] Further, even in the case that no engine install occurs, a problem arises that the engine rotation speed is unnecessarily increased which may lead to a worsening of the fuel efficiency.

[0008] The present invention was made in consideration with the above problems and the object of the invention is to provide a vehicular drive apparatus for a vehicle equipped with the manual clutch, which improves the control responsibility and thereby to prevent an engine stall.

[Solution to Problem(s)]

[0009] The vehicular drive apparatus associated with the invention of claim 1 includes an engine outputting an engine torque to an output shaft, an engine operating means operated for variably outputting the engine torque from the engine, an input shaft which rotates in association with a rotation of a drive wheel of a vehicle, a clutch provided between the output shaft and the input shaft for controlling a clutch transmitting torque therebetween to be variable, a clutch operating means for operating the clutch to control the clutch transmitting torque to be variable, a clutch transmitting torque obtaining means for obtaining the clutch transmitting torque which is generated by the clutch, a required engine torque calculating means for calculating a required engine torque which corresponds to a required torque of the engine based on an operating amount of the engine operating means, a start engine torque calculating means for calculating a start engine torque based on the clutch transmitting torque obtained by the transmitting torque obtaining means and an engine control means for controlling the engine to execute a torque-up control so that the engine torque becomes the start engine torque, when a clutch difference rotation speed which is a difference in rotation speed between the input shaft and the output shaft is equal to or more than a predetermined defined difference rotation speed and at the same time the engine rotation speed is less than a first defined rotation speed and for controlling the engine to execute a normal control so that the engine torque becomes the required engine torque when the clutch difference rotation speed is less than the predetermined defined difference rotation speed.

[0010] The vehicular drive apparatus associated with the invention of claim 2 is characterized in that in claim 1, the vehicular drive apparatus further comprises an engine rotation speed increase necessary torque calculating means for calculating an engine rotation speed increase necessary torque which corresponds to a necessary torque for increasing the engine rotation speed, wherein the start engine toque calculating means calculates the start engine torque based on the engine rotation speed increase necessary torque.

[0011] The vehicular drive apparatus associated with the invention of claim 3 is characterized in that in claim 1 or 2, the vehicular drive apparatus further comprises a load obtaining means for obtaining a load acting on the engine and a maintaining torque calculating means for calculating a maintaining torque which corresponds to a torque necessary for maintaining the engine rotation speed other than the clutch transmitting torque and the engine rotation speed increase necessary torque based on the load, wherein the start engine torque calculating means calculates the start engine torque based on the maintaining torque.

[0012] The vehicular drive apparatus associated with the invention of claim 4 is characterized in that in any one of claims 1 through 3, the engine control means controls the engine so that the engine torque becomes the required engine torque when the engine torque is larger than the start engine torque.

[0013] The vehicular drive apparatus associated with the invention of claim 5 is characterized in that in any one of claims 1 through 4, the vehicular drive apparatus further comprises a corrected start engine torque calculating means for calculating a corrected start engine torque which is more influenced by the required engine torque than the start engine torque, as the engine rotation speed becomes closer to a second defined rotation speed from the first defined rotation speed based on the start engine torque and the required engine torque when the engine rotation speed is equal to or more than the first defined rotation speed and is less than the second defined rotation speed which is faster than the first defined rotation speed, wherein the engine control means controls the engine to execute a limited torque-up control so that the engine torque becomes the corrected start engine torque when the engine rotation speed is equal to or more than the first defined rotation speed and is less than the second defined rotation speed and controls the engine to execute the normal control when the engine rotation speed is equal to or more than the second defined rotation speed.

[0014] The vehicular drive apparatus associated with the invention of claim 6 is characterized in that in any one of claims 1 through 5, the vehicular drive apparatus further comprises a braking force applying means for applying a braking force to the vehicle and a braking force operating means for variably controlling the braking force of the braking force applying means, wherein, the engine control means executes the normal control when the braking force operating means is in operation.

[0015] The vehicular drive apparatus associated with the invention of claim 7 is characterized in that in any one of claims 1 through 6, the clutch transmitting torque obtaining means includes a clutch operating amount detecting means for detecting an operating amount of the clutch operating means.

[0016] The vehicular drive apparatus associated with the invention of claim 8 is characterized in that in any one of claims 1 through 7, the second defined rotation speed is set so that the second defined rotation speed becomes faster as the operating amount of the engine operating means increases.

[0017] The vehicular drive apparatus associated with the invention of claim 9 is characterized in that in any one of claims 2 through 8, the engine rotation speed increase necessary torque is set based on the operating amount of the engine operating means.

[0018] The vehicular drive apparatus associated with the invention of claim 10 is characterized in that in any one of claims 1 through 9, the vehicular drive apparatus further includes a vehicle speed detecting means for detecting a vehicle speed of a vehicle and wherein the engine control means executes the normal control when the vehicle speed detected by the vehicle speed detecting means is faster than a predetermined defined speed.

[Advantageous effects of invention]

[0019] According to the invention associated with claim 1, the start engine torque calculating means calculates the start engine torque based on the clutch transmitting torque. The engine control means controls the engine so that the engine torque becomes the start engine torque when the clutch is in a half-engaged state at which the clutch difference rotation speed is equal to or more than the defined difference rotation speed and at the same time the engine rotation speed is less than the first defined rotation speed.

[0020] Thus, at the vehicle start when the clutch is in the half-engaged state, the engine is controlled so that the engine torque becomes the start engine torque calculated in response to the clutch transmitting torque. Thus, when the clutch transmitting torque is increased, the start engine torque also increases. Therefore, the start engine torque can be increased before a drop of the engine rotation speed derived from the increase of the clutch transmitting torque and thereby a response delay and a drop of the engine rotation speed can be prevented to eventually prevent the engine from occurrence of engine stall.

[0021] According to the invention associated with claim 2, the engine rotation speed increase necessary torque calculating means calculates the engine rotation speed increase necessary torque which is a necessary torque for increasing the engine rotation speed and the start engine torque calculating means calculates the start engine torque based on the engine rotation speed increase necessary torque.

[0022] Thus, under the clutch being in the half-engaged state, the start engine torque which is added by the engine rotation speed increase necessary torque which is necessary for increasing the engine rotation speed is calculated. Accordingly, under such clutch being in half-engaged state, the engine rotation speed can be increased to a most suitable rotation speed or can be kept to the suitable value. As a result, the drop of the engine rotation speed can be prevented and a suitable vehicle starting operability can be kept by preventing an engine stall.

[0023] According to the invention associated with claim 3, the maintaining torque calculating means calculates the maintaining torque based on the load acting on the engine and the start engine torque calculating means calculates the start engine torque based on the maintaining torque.

[0024] Thus, when a load on the engine is increased due to, for example, an operation of an auxiliary machine which is driven by the engine, the start engine torque which is added by the maintaining torque based on the increased load is calculated. Accordingly, under the clutch being in half-engaged state, the engine rotation speed can be increased to a most suitable rotation speed or can be kept to such value. As a result, the drop of the engine rotation speed can be prevented and the engine stall can be more suitably prevented. Further, a suitable starting operability can be kept thereby.

[0025] According to the invention associated with claim 4, the engine control means controls the engine so that the engine torque becomes the required engine torque when the required engine torque is larger than the start engine torque.

[0026] Thus, when the required engine torque is larger than the start engine torque, i.e., when the operator of the vehicle is operating the vehicle not to be in engine stall state, the engine torque is controlled so that the engine torque becomes the required engine torque, reflecting the intention of the operator of the vehicle. Therefore, when the operator of the vehicle is operating the vehicle suitably, the engine torque behavior according to the operation of the acceleration pedal agrees with the intention of the operator. Thus, the engine stall can be prevented without giving any different feeling to the operator of the vehicle.

[0027] According to the invention associated with claim 5, the corrected start engine torque calculating means calculates the corrected start engine torque which is more influenced by the required engine torque than the start engine torque, as the engine rotation speed becomes closer to the second defined rotation speed from the first defined rotation speed when the engine rotation speed is equal to or more than the first defined rotation speed and is less than the second defined rotation speed. Further, the engine control means controls the engine so that the engine torque becomes the corrected start engine torque. Further, the engine control means executes the normal control in which the engine torque agrees with the required engine torque at the time the engine rotation speed reached to the second defined rotation speed, where the start engine torque has no influence (zero).

[0028] Thus, at the start of the vehicle, when the intervening to the engine torque control is to be finished at the second defined rotation speed, while the engine rotation speed is gradually increased from the idling rotation speed, the execution of control is transited from the torque-up control to the normal control through the limited torque-up control where the influence of the torque-up by the torque-up control is gradually decreased. Therefore, a sudden change of the engine torque can be prevented and yet the controlling intervening can be performed within the minimum necessary engine rotation speed. This can minimize an unpleasant feeling of the operator of the vehicle.

[0029] According to the invention associated with claim 6, the engine control means executes the normal control when the braking force operating means is in operation.

[0030] Thus, when the braking force operating means is operated, and the braking force is applied to the vehicle, no torque-up control or limited torque-up control is executed which can prevent the engine install. Therefore, for example, when a vehicle has to be stopped by an emergency braking operation, torque-up control is not forcibly executed on the engine and accordingly, the vehicle can be safely stopped.

[0031] According to the invention associated with claim 7, the clutch transmitting torque obtaining means is a clutch operating amount detecting means which detects the operating amount of the clutch operating means. Therefore, the operating amount of the clutch operating means can be obtained by using a simple structure.

[0032] According to the invention associated with claim 8, the second defined rotation speed is set such that the more the operating amount of the engine operating means, the faster the second defined rotation speed becomes.

[0033] Thus, when the operator of the vehicle is operating the engine operating means largely to request faster engine rotation speed, the upper limit of the engine rotation speed up to which the limited torque-up control intervenes becomes faster. Therefore, even the upper limit of the engine rotation speed is raised in which the engine torque is increased by the limited torque-up control compared to the normal control, the operator of the vehicle does not feel any different feeling. Therefore, by minimizing the different feeling of the operator, the engine rotation speed area where the limited torque-up control intervenes can be increased to surely prevent the engine install.

[0034] According to the invention associated with claim 9, the engine rotation speed increase necessary torque is set based on the operating amount of the engine operating means.

[0035] Thus, when the operator of the vehicle is operating the engine operating means largely to request faster engine rotation speed, start engine torque that increases the engine rotation speed is calculated. Therefore, the engine rotation speed is controlled according to the intention of the operator of the vehicle to give no different or unpleasant feeling to the operator.

[0036] According to the invention associated with claim 10, the engine control means executes the normal control when the vehicle speed detected by the vehicle speed detecting means is faster than the predetermined defined speed.

[0037] Thus, when the vehicle speed is faster than the defined vehicle speed where the engine stall would not be generated, the torque-up or limited torque-up control is not executed. Therefore, with a vehicle speed that would never generate engine stall, if the operator of the vehicle operates the clutch to be in the half-engaged state, unintentional torque-up or limited torque-up control is not executed to give no unpleasant feeling to the operator of the vehicle.

[Brief Explanation of Attached Drawings]

[0038]

[Fig. 1] Fig. 1 is a schematic structural view of a vehicular drive apparatus according to an embodiment of the invention;
[Fig. 2] Fig. 2 illustrates "a clutch transmitting torque mapping data" illustrating a relationship between the clutch stroke and the clutch transmitting torque;
[Fig. 3] Fig. 3 is a graph illustrating an overall structure of the embodiment, wherein the horizontal axis indicates elapsed time and the vertical axis indicates engine rotation speed, engine torque, clutch transmitting torque and acceleration opening degree;
[Fig. 4A] Fig. 4A is a schematic view illustrating a start engine torque Tes1;
[Fig. 4B] Fig. 4B is a schematic view illustrating a start engine torque Tes1;
[Fig. 5] Fig. 5 is a flowchart of "a clutch/engine cooperative control";
[Fig. 6] Fig. 6 illustrates "a second defined rotation speed setting data" which is one example of a mapping data illustrating a relationship between the acceleration opening degree Ac and the second defined rotation speed N2;
[Fig. 7] Fig. 7 is a flowchart of "the torque-up control" which is a sub-routine of "the clutch/engine cooperative control" shown in Fig. 5;
[Fig. 8] Fig. 8 is a flowchart of "engine rotation speed increase necessary torque calculating process" which is a sub-routine of "the torque-up control" shown in Fig. 7;
[Fig. 9] Fig. 9 illustrates "a target engine rotation speed setting data" which is one example of a mapping data illustrating a relationship between the acceleration opening degree Ac and the target engine rotation speed Net;
[Fig. 10] Fig. 10 is a flowchart of "maintaining torque calculating process" which is a sub-routine of the torque-up control" shown in Fig. 7;
[Fig. 11] Fig. 11 illustrates "a compressor auxiliary machine torque calculating data" which is one example of a mapping data illustrating a relationship between the engine rotation speed Ne and the compressor auxiliary machine torque Tac;
[Fig. 12] Fig. 12 is a flowchart of "limited torque-up control" which is a sub-routine of "the clutch/engine cooperative control" shown in Fig. 5;
Fig. 13] Fig. 13 illustrates "an engine rotation speed increase necessary torque calculating data" which is one example of a mapping data illustrating a relationship between a difference rotation speed between a target engine rotation speed Net and a current engine rotation speed Ne and engine rotation speed increase necessary torque Ten; and
[Fig. 14] Fig. 14 is a table explaining a vehicle state at the time of starting.

[Embodiments for Implementing Invention]

(Explanation of vehicle)

[0039] The vehicular drive apparatus 1 according to the embodiment of the invention will be explained with reference to Fig. 1. Fig. 1 illustrates an overall structure of the vehicular drive apparatus 1 equipped with an engine 2. In Fig. 1, the bold lines indicate mechanical connection between the devices and arrows with broken lines indicate signal lines for controlling.

[0040] As shown in Fig. 1, the vehicle is equipped with the engine 2, a clutch 3, a manual transmission 4 and a differential device 17, in series in this order of arrangement. The differential device 17 is connected to drive wheels 18R and 18L of the vehicle. The drive wheels 18R and 18L indicate either front, rear or front/rear wheels of the vehicle.

[0041] The vehicle includes an acceleration pedal 51, a clutch pedal 53 and a brake pedal 56. The acceleration pedal 51 is operated to variably change the engine torque Te outputted from the engine 2. The acceleration pedal 51 is provided with an acceleration sensor 52 which detects the acceleration opening degree Ac which corresponds to an operating amount of the acceleration pedal 51.

[0042] The clutch pedal 53 operates the clutch 3 to be in a disconnected state and in a connected state and is operated to variably change a clutch transmitting torque Tc, which will be explained later. The vehicle further includes a master cylinder 55 which generates a hydraulic pressure corresponding to the operating amount of the clutch pedal 53. The master cylinder 55 is provided with a clutch sensor 54 which detects a stroke of the master cylinder 55.

[0043] The brake pedal 56 is provided with a brake sensor 57 which detects an operating amount of the brake pedal 56. The vehicle includes a brake master cylinder (not shown) which generates a hydraulic pressure responding to the operating amount of the brake pedal 56 and a brake device 19 which applies the wheels of the vehicle with a braking force according to the master pressure generated by the brake master cylinder.

[0044] The engine 2 is such as a gasoline engine or a diesel engine using hydrocarbon system fuel, such as gasoline or light oil. The engine 2 includes an output shaft 21, a throttle valve 22, an engine rotation speed sensor 23, an oil temperature sensor 25 and a fuel injection device 28. The output shaft 21 is rotated unitary with a crank shaft which is rotatably driven by a piston. Thus, the engine 2 outputs the engine torque Te to the output shaft 21. It is noted that when the gasoline engine is used as the engine 2, an ignition device (not shown) is provided on a cylinder head of the engine 2 for igniting an air-fuel mixture gas in the cylinder.

[0045] The throttle valve 22 is provided in a pathway which supplies the cylinder of the engine 2 with the air. The throttle valve 22 is used for adjusting the supplied air amount in the cylinder of the engine 2. The fuel injection device 28 is provided at a pathway which supplies inside of the engine 2 with the air or at the cylinder head of the engine 2. The fuel injection device 28 is used for injecting the fuel such as gasoline or the light oil.

[0046] The engine rotation speed sensor 23 is provided in the vicinity of the output shaft 21. The engine rotation speed sensor 23 detects the engine rotation speed Ne which corresponds to the rotation speed of the output shaft 21 and outputs the detected signal to a control portion 10. The oil temperature sensor 25 detects the oil temperature "t" of the engine oil used for lubricating the engine 2. The detected signal is outputted to the control portion 10. It is noted here that in this embodiment, the output shaft 21 of the engine 2 is connected to a flywheel 31 which is an input member of the clutch 3 which will be explained later.

[0047] The output shaft 21 or a shaft or a gear rotated in association with the output shaft 21 is connected to a generator 26 and a compressor 27a of an air-conditioner 27. The generator 26 generates the electric power necessary for the vehicle.

[0048] The cutch 3 is provided between the output shaft 21 of the engine 2 and a transmission input shaft 41 of the manual transmission 4 which will be explained later. The clutch 3 is a manually operated type clutch which connects or disconnects the output shaft 21 and the transmission input shaft 41 by the operation of the clutch pedal 53 by the operator of the vehicle and at the same time variably changes the clutch transmitting torque Tc (See Fig. 2) between the output shaft 21 and the transmission input shaft 41. The clutch 3 includes the flywheel 31, a clutch disc 32, a clutch cover 33, a diaphragm spring 34, a pressure plate 35, a clutch shaft 36, a release bearing 37 and a slave cylinder 38.

[0049] The flywheel 31 is of a disc plate shape and is connected to the output shaft 21. The clutch shaft 36 is connected to the transmission input shaft 41. The clutch disc 32 is of a disc plate shape and is provided with a friction material 32a at the outer peripheral surfaces of both sides of the clutch disc 32. The clutch disc 32 faces with the flywheel 31 and is in spline connection with the clutch shaft 36 at the tip end thereof allowing slidable movement in an axial direction but restricting rotation relative to the clutch shaft 36.

[0050] The clutch cover 33 is formed by a flattened cylindrical shaped cylindrical portion 33a and a plate portion 33b extending in a rotation center direction from one end of the cylindrical portion 33a. The other end of the cylindrical portion 33a is connected to the flywheel 31. Therefore, the clutch cover 33 is rotated together with the flywheel 31. The pressure plate 35 is of a disc shape having a hole at the center thereof. The pressure plate 35 is provided at the opposite side of the flywheel 31 and facing to the cutch disc 32 and is slidably movable in an axial direction. The clutch shaft 36 is inserted into the pressure plate 35 at the central portion thereof.

[0051] The diaphragm spring 34 is formed by a ring shaped ring portion 34a and a plurality of plate spring portions 34b which is extending toward inside from an inner peripheral brim of the ring portion 34a. The plate spring portions 34b are gradually inclined towards the inside so as to be positioned on the plate portion 33b side. The plate spring portions 34b are elastically deformable in an axis line direction. The diaphragm spring 34 is disposed between the pressure plate 35 and the plate portion 33b of the clutch cover 33 under being compressed state in an axial direction. The ring portion 34a is in contact with the pressure plate 35. The center portion of the plate spring portion 34b is connected to the inner peripheral brim of the plate portion 33b. The clutch shaft 36 is inserted into the central portion of the diaphragm spring 34.

[0052] The release bearing 37 is attached on a housing (not shown) of the clutch 3. The clutch shaft 36 is inserted into the central portion of the release bearing 37 and is slidably movable in an axial direction. The release bearing is provided with a first member 37a and a second member 37b which are oppositely provided and relatively rotatable. The first member 37a is in contact with the tip end of the plate portion 33b.

[0053] The slave cylinder 38 includes a push rod 38a which advances and retreats by the hydraulic pressure. The tip end of the push rod 38a is in contact with the second member 37b of the release bearing 37. The slave cylinder 38 and the master cylinder 55 are connected with each other by a hydraulic pressure conduit 58.

[0054] Under the clutch pedal 53 being not depressed, no hydraulic pressure is generated at the master cylinder 55 and the slave cylinder 38. Under this state, the clutch disc 32 is biased towards the flywheel 31 pushed thereto by the diaphragm spring 34 via the pressure plate 35. Accordingly, the flywheel 31, the clutch disc 32 and the pressure plate 35 are integrally rotated by the friction force generated between the friction material 32a and the flywheel 31 and the friction force generated between the friction material 32a and the pressure plate 35. Thus, the output shaft 21 and the transmission input shaft 41 are connected for unitary rotation.

[0055] On the other hand, when the clutch pedal 53 is depressed, hydraulic pressure is generated in the master cylinder 55 and then also generated in the slave cylinder 38. By this hydraulic pressure, the push rod 38a of the slave cylinder 38 pushes the release bearing 37 towards the diaphragm spring 34 side. Then the plate spring portion 34b is deformed at a connecting portion thereof with the inner peripheral brim of the plate portion 33b as a fulcrum point. Then the biasing force for biasing the clutch disc 32 to the flywheel 31 becomes weak and finally becomes zero.

[0056] As shown in Fig. 2, as the clutch stroke which corresponds to the stroke of the master cylinder 55 increases, the clutch transmitting torque Tc which is transmitted by the clutch 3 from the output shaft 21 to the transmission input shaft 41 becomes small and when the biasing force above becomes zero, the clutch transmitting torque Tc becomes zero and the clutch 3 becomes in fully (completely) disconnected state. Thus as explained, the clutch 3 according to the embodiment is a normally closed type clutch, in which the clutch 3 is in connected state when the clutch pedal 53 is not depressed.

[0057] The manual transmission 4 is a stepped stage transmission wherein a plurality of speed stages respectively having different gear ratios is selectively shifted over between the transmission input shaft 41 and a transmission output shaft 42. A plurality of idle gears (not shown) which is idly rotatable relative to the axis and a plurality of fixed gears (not shown) engaging with the idle gears, whose idle rotation relative to the axis is restricted, are attached to either one of the transmission input shaft 41 and the transmission output shaft 42.

[0058] Further, the manual transmission 4 is provided with a select mechanism wherein one of the plurality of idle gears is selected and the selected gear is restricted relative rotation to the shaft on which the selected gear is fitted. By this structure, the transmission input shaft 41 is rotated in association with the drive wheels 18R and 18L. Further, the manual transmission 4 is provided with a shift operation mechanism (not shown) in which the operation of the shift lever 45 by the operator of the vehicle is converted into a force for operating the select mechanism.

[0059] A transmission input shaft rotation speed sensor 43 is provided in the vicinity of the transmission input shaft 41 for detecting the rotation speed of the transmission input shaft 41 (transmission input shaft rotation speed Ni). The transmission input shaft rotation speed Ni (clutch rotation speed Nc) detected by the transmission input shaft rotation speed sensor 43 is outputted to the control portion 10.

[0060] A transmission output shaft rotation speed sensor 46 is provided in the vicinity of the transmission output shaft 42 for detecting the rotation speed of the transmission output shaft 42 (transmission output shaft rotation speed No). The transmission output shaft rotation speed No detected by the transmission output shaft rotation speed sensor 46 is outputted to the control portion 10.

[0061] The control portion 10 controls the vehicle as a whole and has a memory portion which is formed by a CPU, RAM, ROM and a memory device formed by a nonvolatile memory (these are not shown). The CPU executes the programs corresponding to the flowcharts indicated in Figs. 5, 7, 8, 10 and 12. The RAM memorizes temporarily the variables which are necessary for executing the programs. The memory portion memorizes the above programs, clutch transmitting torque mapping data shown in Fig. 2 and the mapping data indicated in Figs. 6, 9, 11 and 13.

[0062] The control portion 10 calculates the required engine torque Ter which corresponds to the engine torque required by an operator of the vehicle based on the acceleration opening degree Ac detected by the acceleration sensor 52 according to the operation of the acceleration pedal 51 by the operator of the vehicle. Then based on the required engine torque Ter, the control portion 10 adjusts the opening degree S of the throttle valve 22 to adjust the suction amount of the air and the fuel injection amount of the fuel injection device 28, and further controls the ignition device.

[0063] By this, the supply amount of the air-fuel mixture including the fuel is adjusted and the engine torque Te outputted from the engine 2 is adjusted to be the required engine torque Ter and at the same time the engine rotation speed Ne is adjusted. It is noted here that when the acceleration pedal 51 is not depressed (acceleration opening degree Ac= 0 (zero)), the engine rotation speed Ne is kept to be the idle rotation speed (for example 700 r.p.m.).

[0064] The control portion 10 calculates the clutch transmitting torque Tc that is the amount that the clutch can transmit to the transmission input shaft 41 from the output shaft 21 by referencing the clutch stroke Cl detected by the clutch sensor 54 to the clutch transmitting torque mapping data which represents the relationship between the clutch stroke Cl and the clutch transmitting torque Tc illustrated in Fig. 2.

[0065] The control portion 10 calculates the vehicle speed V based on the transmission output shaft rotation speed No detected by the transmission output shaft rotation speed sensor 46. The control portion 10 calculates the clutch difference rotation speed Δc which corresponds to the difference rotation speed of the clutch 3 by subtracting the transmission input shaft rotation speed Ni detected by the transmission input shaft rotation speed sensor 43 from the engine rotation speed Ne detected by the engine rotation speed sensor 23. In other words, the clutch difference rotation speed Δc is the difference rotation speed of the clutch 3, i.e., the difference rotation speed between the output shaft 21 and the transmission input shaft 41.

[0066] The vehicular drive apparatus 1 according to the embodiment is a structure which includes the engine 2, clutch 3, manual transmission 4, control portion 10, clutch pedal 53, clutch sensor 54, master cylinder 55, acceleration pedal 51, acceleration sensor 52, brake pedal 56, brake sensor 57 and hydraulic pressure conduit 58.

(Outline of the embodiment)

[0067] The outline of the embodiment of the invention will be explained with reference to Figs. 3 and 4. Under the vehicle starting, when the vehicle speed V is equal to or less than a predetermined value, the brake pedal 56 is not depressed and the clutch difference rotation peed Δc is equal to or more than a predetermined value, in other words, when the vehicle is in a start state and the clutch 3 is half-engaged state, in other words, when the engine 2 is in a state where an engine stall that the engine 2 stops may occur, the torque-up control is executed.

[0068] The torque-up control means, as shown in Fig. 3, is a controlling for increasing the engine torque Te (See line 3 of Fig. 3) as indicated with the solid line 2 in Fig. 3 compared to the engine torque Te (torque indicated with a dot-chain line 1 in Fig. 3) based on the required engine torque Ter calculated based on the operation of the acceleration pedal 51 by the operator of the vehicle.

[0069] As stated above, when there is a possibility that the engine stall, the engine 2 stopping, happens or when the starting operation is carelessly made with a low engine rotation speed, by increasing the engine torque Te generated by the engine 2 (See line 3 in Fig. 3), engine stall can be prevented and at the same time suitable engine rotation speed is kept automatically to start the vehicle.

[0070] In detail, when the vehicle is starting, the control portion 10 performs differently from the other situations, to calculate the start engine torque Tes1 by adding the clutch transmitting torque Tc, the engine rotation speed increase necessary torque Ten and the maintaining torque Tk as shown in Fig. 4. Then the control portion 10 controls the engine 2 so that the engine torque Te agrees with the start engine torque Tes1.

[0071] It is noted here that the engine rotation speed increase necessary torque Ten is a torque necessary for increasing the engine rotation speed to the target engine rotation speed Net, i.e., the torque necessary for increasing the engine rotation speed to an optimum rotation speed for starting the vehicle. The maintaining torque Tk is a torque necessary for maintaining the target engine rotation speed Net while the torque-up control and a limited torque-up control which will be later explained are executed other than the clutch transmitting torque Tc and the engine rotation speed increase necessary torque Ten.

[0072] From the state shown in Fig. 4A, when the operator of the vehicle suddenly releases the clutch pedal 53 to thereby suddenly increasing the clutch transmitting torque Tc, the start engine torque Tes1 increases along with the increase of the clutch transmitting torque Tc, as shown in Fig. 4B. In other words, according to this embodiment, when the clutch transmitting torque Tc increases, the start engine torque Tes1 increases before the drop of the engine rotation speed Ne. Accordingly, the drop of the engine rotation speed Ne can be prevented and further the engine stall can be avoided and at the same time the suitable engine rotation speed can be maintained. This will be further explained in more detail with reference to the flowchart in Fig. 5.

(Clutch/engine cooperative control)

[0073] The clutch/engine cooperative control is explained hereinafter using the flowchart in Fig. 5. When an ignition key of the vehicle is NO and the engine 2 is started, the clutch/engine cooperative control starts and the program goes to the step S11.

[0074] At the step S11, when the control portion 10 judges that the brake pedal 56 is not depressed and the brake device 19 does not generate the braking force (Brake OFF) based on the detection signal from the brake sensor 57 (S11; YES), the control portion 10 advances the program to the step S12. On the other hand, when the control portion 10 judges that the brake pedal 56 is depressed and the brake device 19 generates the braking force (Brake ON), (S11; NO), the control portion 10 advances the program to the step S18.

[0075] At the step S12, when the control portion 10 judges that the clutch transmitting torque Tc is not zero (clutch 3 is not completely disconnected) based on the detection signal from the clutch sensor 54 (S12; YES), the control portion

10 advances the program to the step S13. On the other hand, when the control portion 10 judges that the clutch transmitting torque Tc is zero (clutch 3 is completely disconnected) (S12; NO), the control portion 10 advances the program to the step S18.

[0076] At the step S13, when the control portion 10 judges that the vehicle speed V is equal to or less than a predetermined defined speed (for example, 20 km/h) (S13; YES), the control portion 10 advances the program to the step S14 and when the control portion 10 judges that the vehicle speed V is faster than the defined speed (S13; NO), the program goes to the step S18.

[0077] At the step S14, when the control portion 10 judges that the clutch difference rotation speed Δc is equal to or more than a defined difference rotation speed A (for example, 500 r.p.m.) based on the detection signals outputted from the engine rotation speed sensor 23 and the transmission input shaft rotation speed sensor 43 (S14; YES), the control portion 10 advances the program to the step S15. On the other hand, when the control portion 10 judges that the clutch difference rotation speed Δc is less than the defined difference rotation speed A (S14; NO), the control portion 10 advances the program to the step S18.

[0078] At the step S15, when the control portion 10 judges that the engine rotation speed Ne is less than a first defined rotation speed N1 (for example, 1100 r.p.m.), the control portion 10 advances the program to the step S16. Further, when the control portion 10 judges that the engine rotation speed Ne is equal to or more than the first defined rotation speed N1 but less than the second defined rotation speed N2, the control portion 10 advances the program to the step S17. When the control portion 10 judges that the engine rotation speed Ne is equal to or more than the second defined rotation speed N2, the program goes to the step S18.

[0079] It is noted here that the second defined rotation speed N2 is set to be faster than the first defined rotation speed N1. The second defined rotation speed N2 is calculated by referencing the second defined rotation speed setting data which represents the relationship between the acceleration opening degree Ac and the second defined rotation speed N2 shown in Fig. 6. In other words, it is set that the greater the acceleration opening degree Ac is, the faster the second defined rotation speed N2 is. The second defined rotation speed N2 is calculated by performing a linear interpolation on the second defined rotation speeds N2 corresponding to the acceleration opening degrees neighboring to the current acceleration opening degree Ac at both sides thereof, when the current acceleration opening degree Ac detected by the acceleration sensor 52 is between the acceleration opening degrees defined in the second defined rotation speed setting data indicated in Fig. 6.

[0080] At the step S16, the control portion 10 executes the torque-up control. This torque-up control will be explained with reference to the flowchart shown in Fig. 7. After the process of the step S16, the program returns to the step S11.

[0081] At the step S17, the control portion 10 executes the limited torque-up control. This limited torque-up control will be explained with reference to the flowchart shown in Fig. 12. After the process of the step S17, the program returns to the step S11.

[0082] At the step S18, when either one of the torque-up control and the limited torque-up control is started, the control portion 10 finishes the control which is in operation and executes the normal engine control. In other words, the control portion 10 controls the engine 2 so that the engine torque Te becomes the required engine torque Ter calculated based on the operation of the acceleration pedal 51 by the operator of the vehicle. After the process of the step S18, the program returns to the step S11.

(Torque-up control)

[0083] The torque-up control will be explained hereinafter with reference to the flowchart in Fig. 7. When the torque-up control starts, the program goes to the step S16-1.

[0084] At the step S16-1, the control portion 10 calculates the clutch transmitting torque Tc by referencing the clutch stroke Cl detected by the clutch sensor 54 to the clutch transmitting torque mapping data shown in Fig. 2. After the process of the step S16-1, the program goes to the step S16-2.

[0085] At the step S16-2, the control portion 10 calculates the engine rotation speed increase necessary torque Ten. The calculation of the engine rotation speed increase necessary torque Ten will be explained with reference to the flowchart of the engine rotation speed increase necessary torque calculation process shown in Fig. 8.

[0086] When the engine rotation speed increase necessary torque calculation process starts, the program goes to the step S21. At the step S21, the control portion 10 calculates the target engine rotation speed Net. The target engine rotation speed Net is a control target of the engine rotation speed Ne and more specifically, the control portion 10 calculates the target engine rotation speed Net by referencing the acceleration opening degree Ac detected by the acceleration sensor 52 to the target engine rotation speed setting data which represents the relationship between the acceleration opening degree Ac and the target engine rotation speed Net.

[0087] In other words, the target engine rotation speed Net is set to be faster as the acceleration opening degree Ac becomes greater. The target engine rotation speed Net is calculated by performing a linear interpolation on the target engine rotation speeds which corresponds to the acceleration opening degrees neighboring to the current acceleration opening degree Ac at both sides thereof, when the current acceleration opening degree Ac detected by the acceleration sensor 52 is between the acceleration opening degrees defined in the target engine rotation speed setting data shown in Fig. 9. After the process of the step S22, the program goes to the step S22.

[0088] At the step S22, the control portion 10 calculates the engine rotation speed change ωe which is a time change of the engine rotation speed Ne. More specifically, the control portion 10 calculates the time Tn necessary for increasing the current engine rotation speed Ne to the target engine rotation speed Net calculated at the step S21, when the engine 2 is used to exercise the maximum available power. Then the control portion 10 calculates the engine rotation speed time change me by dividing the value obtained by subtracting the current engine rotation speed Ne from the target engine rotation speed Net by the necessary time Tn. After the process of the step S22, the program goes to the step S23.

[0089] At the step S23, the control portion 10 calculates the engine rotation speed increase necessary torque Ten based on the following formula (1).

$$Ten = Ie \times \omega e \ldots\ldots\ldots (1)$$

Ten......Engine rotation speed increase necessary torque Ten
Ie.......Engine inertia
ωe....engine rotation speed change

[0090] The engine inertia Ie is a moment of inertia of a rotation member of the engine 2. Such rotation member of the engine 2 includes crank shaft, con-rod, piston, output shaft 21, flywheel 31, clutch cover 33, pressure plate 35 and diaphragm spring 34. The engine inertia Ie is predetermined in advance. After the process of the step S23, process at the step S16-2 in Fig. 7 ends and the program goes to the step S16-3.

[0091] At the step S16-3, the control portion 10 calculates the maintaining torque Tk. This maintaining torque Tk is a necessary torque for maintaining the target engine rotation speed Net other than the clutch transmitting torque Tc and the engine rotation speed increase necessary torque Ten. The calculation of the maintaining torque Tk will be explained with reference to the flowchart of the maintaining torque calculating process shown in Fig. 10.

[0092] When the maintaining torque calculating process starts, the program goes to the step S31. At the step S31, the control portion 10 calculates the engine friction torque Tef based on the current oil temperature "t" and the current engine rotation speed Ne. After the process at the step S31 ends, the program goes to the step S32.

[0093] At the step S32, the control portion 10 calculates the auxiliary machine torque Ta. The auxiliary machine torque Ta is a torque necessary for driving an auxiliary machine which is connected to the output shaft 21 of the engine 2 and is represented as the total torque of the friction torque and the inertia torque of the auxiliary machine. A method for calculating a compressor auxiliary machine torque Tac of a compressor 27a of an air-conditioner 27 will be explained hereinafter as an example of an auxiliary machine. The control portion 10 calculates the compressor auxiliary machine torque Tac by referencing the current engine rotation speed Ne to the "compressor auxiliary machine torque calculating data" which represents the relationship between the engine rotation speed and the compressor auxiliary machine torque shown in Fig. 11.

[0094] It is noted that the compressor auxiliary machine torque Tac is set to be greater as the engine rotation speed Ne becomes faster. Further, the compressor auxiliary machine torque Tac is largely set where the air-conditioner is ON, as compared to the case where the air-conditioner is OFF. The compressor auxiliary machine torque Tac is calculated by performing a linear interpolation on the compressor auxiliary machine torques corresponding to the engine rotation speeds neighboring to the current engine rotation speed Ne at both sides thereof, when the current engine rotation speed Ne is between the engine rotation speeds defined in the compressor auxiliary machine torque calculating data indicated in Fig. 11.

[0095] Similar to the calculating method as that for the compressor auxiliary torque Tac, the control portion 10 calculates a generator auxiliary torque Tag of the generator 26 which is another example of the auxiliary machines and an auxiliary machine torque of the auxiliary machine connected to the output shaft 21 of the engine 2. The control portion 10 calculates the auxiliary machine torque Ta by summing up the compressor auxiliary machine torque Tac and the generator auxiliary machine torque Tag and so on. After the process of the step S32, the program goes to the step S33.

[0096] At the step S33, the control portion 10 calculates the adjusting torque "α". The adjusting torque α is a necessary torque other than the engine friction torque Tef and the auxiliary machine torque Ta and is calculated based on the information regarding the engine rotation speed Ne or the like. After the process of the step S33, the program goes to the step S34.

[0097] At the step S34, the control portion 10 calculates the maintaining torque Tk based on the following formula (2).

$$Tk = Tef + Ta + T\alpha........(2)$$

Tk.....Maintaining torque
Tef....Engine friction torque
Ta.....Auxiliary machine torque
$T\alpha$.....Adjusting torque

[0098] After the process of the step S34, the process at the step S16-3 ends and the program goes to the step S16-4.
[0099] At the step S16-4, the control portion 10 calculates the start engine torque Tes1 based on the following formula (3).

$$Tes1 = Tc + Ten + Tk...........(3)$$

Tes1...Start engine torque
Tc.....Clutch transmitting torque
Ten.....Engine rotation speed increase necessary torque
Tk.....Maintaining torque.

[0100] After the process of the step S16-4, the program goes to the step S16-5.
[0101] At the step S16-5, when the control portion 10 judges that the start engine torque Tes1 is larger than the required engine torque Ter (S16-5; YES), the program goes to the step S16-6 and when the control portion 10 judges that the start engine torque Tes1 is equal to or less than the required engine torque Ter (S16-5; NO), the program goes to the step S16-7.
[0102] At the step S16-6, the control portion 10 controls the throttle valve 22, fuel injection device 28 and the ignition device so that the engine torque Te which the engine 2 generates becomes the start engine torque Tes1 calculated at the step S16-4. After the process of the step S16-6, the program returns to the step S11 in Fig. 5.
[0103] At the step S16-7, the control portion 10 controls the throttle valve 22, fuel injection device 28 and the ignition device so that the engine torque Te which the engine 2 generates becomes the required engine torque Ter. After the process of the step S16-8, the program returns to the step S11 in Fig. 5.

(Limited torque-up control)

[0104] The limited torque-up control will be explained hereinafter with reference to the flowchart shown in Fig. 12. When the limited torque-up control starts, the program goes to the step S17-1.
[0105] At the step S17-1, the control portion 10 calculates the start engine torque Tes1. It is noted that the method for calculating the start engine torque Tes1 is the same with the method at the steps S16-1 through S16-4 in the torque-up control shown in Fig. 7. After the process of the step S17-1, the program goes to the step S17-2.
[0106] At the step S17-2, the control portion 10 corrects the start engine torque Tes1 based on the current engine torque Ne. The detail thereof will be explained hereinafter. The control portion 10 calculates the first rotation speed difference Δa by subtracting the first defined rotation speed N1 from the current engine rotation speed Ne (point "4" in Fig. 3) based on the following formula (4):

$$\Delta a = Ne - N1...... (4)$$

Δa: First rotation speed difference
Ne: Current engine rotation speed
N1: First defined rotation speed.

[0107] Next, the control portion 10 calculates the second rotation speed difference Δb by subtracting the current engine rotation speed Ne (point "4" in Fig. 3) from the second defined rotation speed N2 based on the following formula (5):

$$\Delta b = N2 - Ne...... (5)$$

Δb: Second rotation speed difference
N2: Second defined rotation speed.
Ne: Current engine rotation speed

[0108] Next, the control portion 10 calculates the corrected start engine torque Tes2 by substituting the required engine torque Ter, the start engine torque Tes1, the first speed rotation difference Δa and the second rotation speed difference Δb into the following formula (6):

$$Tes2 = (Tes1 \times \Delta b + Ter \times \Delta a) / (\Delta a + \Delta b) \ldots (6)$$

Tes2: Corrected start engine torque
Tes1: Start engine torque
Ter: Required engine torque
Δa: First rotation speed difference
Δb: Second rotation speed difference

[0109] After the process of the step S17-2, the program goes to the step S17-3.

[0110] At the step S17-3, when the control portion 10 judges that the corrected start engine torque Tes2 is larger than the required engine torque Ter (S17-3; YES), the program goes to the step S17-4 and when the control portion 10 judges that the corrected start engine torque Tes2 is equal to or less than the required engine torque Ter (S17-3; NO), the program goes to the step S17-5.

[0111] At the step S17-4, the control portion 10 controls the throttle valve 22, fuel injection device 28 and the ignition device so that the engine torque Te which the engine 2 generates becomes the corrected start engine torque Tes2 calculated at the step S17-2. After the process of the step S17-4, the program returns to the step S11 in Fig. 5.

[0112] At the step S17-5, the control portion 10 controls the throttle valve 22, fuel injection device 28 and the ignition device so that the engine torque Te which the engine 2 generates becomes the required engine torque Ter. After the process of the step S17-5, the program returns to the step S11 in Fig. 5.

(Explanation of the vehicle start)

[0113] The clutch/engine cooperative control at the start of the vehicle will be explained hereinafter using Figs. 2, 5 and 13.

<Time elapsed T1>

[0114] Under this state, since the brake pedal 56 is depressed, the judgment at the step S11 in Fig. 5 is "NO" and accordingly, the engine 2 control is subject to the acceleration operation by the operator of the vehicle. Under this state, since the acceleration pedal 51 is not depressed, the engine rotation speed Ne is under an idle rotation speed (for example, 700 r.p.m.).

<Time elapsed T2>

[0115] Under this state, since the clutch 3 is completely disconnected, the judgment at the step S12 in Fig. 5 is "NO" and accordingly, the engine 2 control is subject to the acceleration operation by the operator of the vehicle. Under this state, since the acceleration pedal 51 is depressed, the engine rotation speed Ne and the engine torque Te are subject to the acceleration opening degree Ac.

<Time elapsed T3>

[0116] Under this state, since the clutch 3 is in half-connected state, the judgment at the step S12 in Fig. 5 is "YES", and since the clutch difference rotation speed Δc is equal to or more than the defined difference rotation speed A (for example, 500r.p.m.), the judgment at the step S14 is "YES". Further, since the engine rotation speed Ne is less than the first defined rotation speed N1 (for example, 1100 r.p.m.), the program goes to the step S16 based on the judgment at the step S14 and the torque-up control starts. At the torque-up control, when the start engine torque Tes1 is judged to be larger than the required engine torque Ter (S16-5 YES in Fig. 7), the engine 2 is controlled to have the start engine control torque Tes1.

<Time elapsed T4>

[0117] Under this state, since the engine rotation speed Ne exceeds the first defined rotation speed N1 (for example, 1100 r.p.m.), according to the judgment at the step S14 in Fig. 5, the program goes to the step S17 and the limited torque-up control starts. Then, under the limited torque-up control, when the corrected start engine torque Tes2 is judged to be greater than the required engine torque Ter (S17-3 in Fig. 12; YES), the engine 2 is controlled so that the engine torque agrees with the corrected start engine torque Tes2.

<Time elapsed T5>

[0118] Under this state, since the engine rotation speed Ne has exceeded the second defined rotation speed N2 (for example, 1400 r.p.m.), according to the judgment at the step S14 in Fig. 5, the program goes to the step S18 to finish the limited torque-up control and the normal engine control starts. Accordingly, the engine 2 is controlled so that the engine torque agrees with the required engine torque Ter calculated based on the acceleration opening degree Ac.

< After Time elapsed T5>

[0119] Thereafter, the clutch difference rotation speed Δc decreases and finally becomes zero due to the synchronization of the clutch 3. Then when the operator of the vehicle releases the clutch pedal 53, the clutch 3 is completely engaged (T7).

(Advantageous effects of the embodiment)

[0120] As apparent from the explanation above, the control portion 10 (start engine torque calculating means) calculates the start engine torque Tes1 based on the clutch transmitting torque Tc at the step S16-4 in Fig. 7. Further, the control portion 10 (engine control means) controls the engine 2 so that the engine torque Te agrees with the start engine torque Tes1 at the step S16-6 in Fig. 7, when the clutch difference rotation speed Δc is judged to be equal to or more than the defined difference rotation speed A, at which the clutch 3 becomes the half-connected state (S14 in Fig. 5: YES).

[0121] As explained, when the start of the vehicle under the clutch 3 being in half-connected state, the engine 2 is controlled to output the start engine torque Tes1 which is calculated corresponding to the clutch transmitting torque Tc. Thus, when the operator of the vehicle suddenly releases the clutch pedal 53 and the clutch transmitting torque Tc becomes increased, the start engine torque Tes1 also increases. Therefore, the start engine torque Tes1 increases before the dropping of the engine rotation speed Ne, due to the increase of the clutch transmitting torque. This can prevent the occurrence of engine stall.

[0122] Further, the control portion 10 (engine rotation speed increase necessary torque calculating means) calculates the engine rotation speed increase necessary torque Ten which is necessary for increasing the engine rotation speed Ne at the engine rotation speed increase necessary torque calculating process in Fig. 8. Further, the control portion 10 (start engine torque calculating means) calculates the start engine torque Tes1 based on the engine rotation speed increase necessary torque Ten at the step S16-4 in Fig. 7.

[0123] Thus, the start engine torque Tes1 is calculated, which includes the engine rotation speed increase necessary torque Ten for increasing the engine rotation speed Ne. Because of this, even when the engine rotation speed Ne drops under the clutch being in half-connected state, the engine rotation speed Ne can be recovered to prevent continuing of the dropping of the engine rotation speed Ne. This can further surely prevent the engine stall.

[0124] Further, the control portion 10 (maintaining torque calculating means) calculates the maintaining torque Tk based on the various loads influencing on the engine 2 by the maintaining torque calculating process shown in Fig. 10. Further, the control portion 10 (start engine torque calculating means) calculates the start engine torque Tes1 based on the maintaining torque Tk at the step S16-4 in Fig. 7.

[0125] Thus, the start engine torque Tes1 is calculated, which includes the maintaining torque Tk calculated based on the increased load applied to the engine 2 by the operation of the auxiliary machines, for example, the generator 26 and the compressor 27a driven by the engine 2. Accordingly, the dropping of the engine rotation speed Ne can be further surely prevented under the clutch being in half-engaged state to further surely prevent the engine stall.

[0126] Further, the control portion 10 (engine control means) controls the engine 2 so that the engine torque agrees with the required engine torque Ter, when the required engine torque Ter is judged to be greater than the start engine torque Tes1 and Tes2 (S16-5 in Fig. 7 and S17-3 in Fig. 12: YES).

[0127] By this processing, when the required engine torque Ter is greater than the start engine torque Tes1 and Tes2, the engine 2 is controlled to output the required engine torque Ter which reflects the intention of the operator of the vehicle. This control can prevent the operator of the vehicle from having an unpleasant feeling because the engine torque Te and the intention of the operator do not differ from each other. In the above case, since the required engine torque

Ter is greater than the start engine torque Tes1, the engine stall would not occur.

[0128] Still further, the control portion 10 (corrected start engine torque calculating means) calculates the corrected start engine torque Tes2 which receives more influence from the required engine torque Ter than the start engine torque Tes1, as more the engine rotation speed Ne approximates closer to the second defined rotation speed from the first defined rotation speed N1 based on the formulae (4) through (6) at the step S17-2 in Fig. 12, when the engine rotation speed Ne is judged to be equal to or more than the first defined rotation speed N1 and less than the second defined rotation speed N2 (Judgment to proceed to the step S17 at the step S15 in Fig. 5). Then the control portion 10 executes the limited torque-up control wherein the engine 2 is controlled so that the engine torque Te agrees with the corrected start engine torque Tes2 at the step S17-4 in Fig. 12.

[0129] Thus, at the vehicle start, when the engine rotation speed Ne is increased gradually from the idling rotation speed, the engine control is transferred from the torque-up control to the normal control via the limited torque-up control where the influence of the torque-up operation by the torque-up control is gradually decreasing. This can prevent the sudden change of the engine torque Te to thereby prevent the operator from feeling unpleasantly.

[0130] Further, the control portion 10 executes the normal control at the step S18, when the brake pedal 56 (braking force operating means) is depressed (S11 in Fig. 5; NO).

[0131] Thus, when the brake pedal 56 is depressed and the braking force is applied to the vehicle, the torque-up control or the limited torque-up control which prevents the engine stall, would not be executed. Accordingly, when the vehicle has to be stopped urgently to perform an emergency braking, a control which forcibly prevents the engine 2 from stalling would not be performed and the vehicle can be safely stopped.

[0132] Further, the clutch stroke Cl which corresponds to the operating amount of the clutch pedal 53 is detected by the clutch sensor 54 (clutch transmitting torque obtaining means). The control portion 10 obtains the clutch transmitting torque Tc by referencing the clutch stroke Cl to the clutch transmitting torque mapping data shown in Fig. 2. Thus, the clutch transmitting torque Tc can be surely obtained with a simple structure and a simple method.

[0133] Further, the control portion 10 obtains the second defined rotation speed N2 by referencing the acceleration opening degree Ac to the second defined rotation speed setting data at the step S15 in Fig. 5. Thus, the second defined rotation speed N2 can be set in a manner that the greater the acceleration opening degree Ac, the faster the second defined rotation speed N2 becomes.

[0134] Thus, when the operator of the vehicle depresses the acceleration pedal 51 deeply to require a large engine torque Te, the upper limit of the engine rotation speed Ne becomes faster during the limited torque-up control intervening. Accordingly, even when the upper limit of the engine rotation speed Ne which more increases the engine torque Te by the limited torque-up control compared to that of the normal control, the operator of the vehicle does not feel any unpleasant feeling. Thus, the area of the engine rotation speed Ne where the limited torque-up control intervenes can be increased keeping the operator not to feel differently. This can further surely prevent the engine from stalling.

[0135] Further, the control portion 10 sets the target engine rotation speed Net which is faster when the acceleration opening degree Ac is greater at the step S21 in Fig. 8, by referencing the acceleration opening degree Ac to the target engine rotation speed setting data shown in Fig. 9. Then the control portion 10 calculates the engine rotation speed increase necessary torque Ten based on the target engine rotation speed Net at the step S22 and the step S23.

[0136] Thus, when the operator of the vehicle depresses the acceleration pedal 51 deeply to require a faster engine rotation speed Ne, the start engine torque Tes1 and Tes2 which increases the engine rotation speed Ne is calculated. Thus the engine rotation speed Ne is controlled along the intention of the operator of the vehicle not to let the operator feel unpleasantly.

[0137] When the control portion 10 judges that the vehicle speed V is faster than the predetermined defined speed (S13; NO) at the step S13 in Fig. 5, the normal control is executed at the step S18.

[0138] Thus, when the vehicle speed V is faster than the defined vehicle speed that would not generate any engine stall, the torque-up control or the limited torque-up control is not executed. Therefore, if the operator of the vehicle accidentally should perform half-clutch operation when the vehicle is running under the vehicle speed which does not generate the engine stall (for example, at the speed of 40km/h), the execution of the torque-up control or the limited torque-up control can be prevented not to give any an unpleasant feeling to the operator of the vehicle.

[0139] Further as explained above, since the start engine torque Tes1 is calculated based on the clutch transmitting torque Tc, a sudden rise of the engine rotation speed Ne under the acceleration pedal being not depressed by the operator of the vehicle can be prevented. Thus, the operator of the vehicle does not have any unpleasant feeling and in addition the worsening of vehicle fuel efficiency derived from the sudden rise of the engine rotation speed Ne can be prevented.

(Other embodiments)

[0140] Other embodiments different from the embodiments explained above will be explained hereinafter. According to the embodiment explained hitherto, the engine rotation speed increase necessary torque Ten is an inertia torque of the engine 2 necessary for raising the current engine rotation speed to the target engine rotation speed and is calculated based on the engine inertia Ie and the engine rotation speed change ωe. However, it may be possible to calculate the engine rotation speed increase necessary torque Ten by referencing the difference rotation speed between the target engine rotation speed Net and the current engine rotation speed Ne to the engine rotation speed increase necessary torque calculating data shown in Fig. 13.

[0141] The engine rotation speed increase necessary torque Ten is set so that the engine rotation speed increase necessary torque Ten becomes greater as the difference rotation speed between the target engine rotation speed Net and the current engine rotation speed Ne becomes greater. Further, when the difference value between the target engine rotation speed Net and the current engine rotation speed Ne is minus value, in other words, when the difference rotation speed of the current engine rotation speed Ne is faster than the target engine rotation speed Net, the engine rotation speed increase necessary torque Ten is zero (0). As same with the embodiment explained above, the engine rotation speed increase necessary torque Ten is calculated by performing a linear interpolation based on the engine rotation speed increase necessary torque calculating data.

[0142] According to the embodiment explained above, the corrected start engine torque Tes2 is calculated by proportionally distributing the required engine torque Ter and the start engine torque Tes1 according to the proportional ratio between the current engine rotation speed and the first or the second defined rotation speed N1 or N2 based on the formula (6) above. However, a different method may be used for calculation of the corrected stat engine torque Tes2, wherein based on the required engine torque Ter and the start engine torque Tes1, the corrected start engine torque Tes2 is calculated so that the closer the engine rotation speed Ne approximates to the first defined rotation speed N1 from the second defined rotation speed N2, the greater the engine rotation speed Ne receives influence from the start engine torque Tes1 than from the required engine torque Ter.

[0143] According to this embodiment, when the current engine rotation speed Ne decreases and differs from the target engine rotation speed Net, larger engine rotation speed increase necessary torque Net is set. Thus, the drop of the engine rotation speed Ne can be surely prevented. Further, when the current engine rotation speed Ne is faster than the target engine rotation speed Net, the engine rotation speed increase necessary torque Ten becomes zero (0) and accordingly, no useless engine rotation speed increase is prevented to improve the fuel efficiency and generation of noise and unpleasant feeling given to the operator of the vehicle can be also prevented.

[0144] According to the embodiment explained above, the operation force of the clutch pedal 53 is transmitted to the release bearing 37 via the master cylinder 55, the hydraulic pressure conduit 58 and the slave cylinder 38. However, the operation force of the clutch pedal 53 may be transmitted to the release bearing 37 through the mechanical elements such as wire, rod and gears.

[0145] According to the embodiment explained above, the clutch transmitting torque Tc is calculated by referencing the clutch stroke Cl detected by the clutch sensor 54 to the clutch transmitting torque mapping data which represents the relationship between the clutch stroke Cl and the clutch transmitting torque Tc as shown in Fig. 2. However, as disclosed in a JP patent publication No. 2008-157184 A, it is possible that the clutch transmitting torque Tc is presumed based on the change amount of the clutch stroke Cl per unit time and then the required engine torque Ter is presumed thereby.

[0146] According to the embodiment explained above, the clutch transmitting torque Tc is calculated based on the detection signal from the clutch sensor 54. However, the clutch transmitting torque Tc may be calculated based on the information such as, the engine inertia Ie, the engine friction torque Tef, the rotation speed of the transmission input shaft 41 at the time the engagement starts, the current rotation speed of the transmission input shaft 41 and a time elapsed from the start of the engagement.

[0147] According to the embodiment explained above, the clutch sensor 54 detects the stroke amount of the master cylinder 55. However, the clutch sensor 54 may be a sensor which detects the operating amount of the clutch pedal 53, master pressure of the master cylinder 55, the stroke or the hydraulic pressure of the slave cylinder 38 or the stroke amount of the release bearing 37.

[0148] According to the embodiment explained above, the control portion 10 calculates the vehicle speed V based on the transmission output shaft rotation speed No detected by the transmission output shaft rotation speed sensor 46. However, the control portion 10 may calculate the vehicle speed V based on the vehicle wheel rotation speed which is detected by the vehicle wheel speed sensor which detects the wheel rotation speed of the vehicle, or a sensor which detects the rotation speed of an axis rotating in association with the vehicle wheel.

[0149] According to the embodiment explained above, an oil temperature of the lubrication oil lubricating the engine 2 is detected by the oil temperature sensor 25. However, the oil temperature may be presumed based on the detection signal from the water temperature sensor which detects the water temperature of cooling water circulating through the engine 2.

[0150] According to the embodiment explained above, the clutch operating member for transmitting the operating force of the operator of the vehicle to the clutch 3 includes the clutch pedal 53. However, the clutch operating member is not limited to the clutch pedal 53, but a clutch lever may be used as the clutch operating member. Similarly, instead of using the acceleration pedal 51 for adjusting the acceleration opening degree Ac, for example, acceleration grip for adjusting the acceleration opening degree Ac may be used. Further, the vehicular drive apparatus according to the embodiment can be apparently used for a motor cycle or other vehicles.

[0151] According to the embodiment explained above, a single unit control portion 10 controls the engine 2 and at the same time executes the clutch/engine cooperative control as shown in Fig. 5. However, as a different embodiment, it is possible that an engine control portion controls the engine 2 and the control portion 10 connected to the engine control portion through a communication means such as CAN (Controller Area Network) executes the clutch/engine cooperative control.

[0152] According to the embodiment explained above, the vehicle includes a manual transmission 4. However, the technical idea of this invention can be applied to a vehicle which does not includes a manual transmission but includes an input shaft which is rotatable in association with the rotation of the drive wheels 18R and 18L and connected to the clutch disc 32.

[0153] According to the embodiment explained above, the invention is applied to the timing of the start of the vehicle, but the invention is applicable to the driving under a very slow vehicle speed situation where an excess dropping of the engine rotation speed is prevented by using the half-clutch operation to appropriately slide the clutch where the vehicle is running in a heavy traffic jam or the vehicle is under garage parking.

[Reference Signs List]

[0154] In the drawings:

1: vehicular drive apparatus, 2: engine, 3: clutch, 10: control portion (required engine torque calculating means, start engine torque calculating means, engine control means, clutch transmitting torque obtaining means, engine rotation speed increase necessary torque calculating means, load obtaining means, maintaining torque calculating means), 19: brake device (braking force applying means), 21: output shaft, 25: oil temperature sensor (load obtaining means), 41:transmission input shaft (input shaft), 46: transmission output shaft rotation speed sensor (vehicle speed detecting means), 51: acceleration pedal (engine operating means), 52: acceleration sensor (required engine torque calculating means), 53: clutch pedal (clutch operating member), 54: clutch sensor (clutch transmitting torque obtaining means, clutch operating amount obtaining means), 56: brake pedal (brake operating means), 57: brake sensor (brake operating amount detecting means),
"t": oil temperature, "V": vehicle speed, "A": defined difference rotation speed, "N1": first defined rotation speed, "N2" second defined rotation speed, "Δc": clutch difference rotation speed, "Te": engine torque, "Ter": required engine torque, "Tes1": start engine torque (at torque-up control), "Tes2": corrected start engine torque (at Limited torque-up control), "Tc": clutch transmitting torque, "Ten": engine rotation speed increase necessary torque, "Tk": maintaining torque, "Ie": engine inertia, "Net": target engine rotation speed, "ωe": engine rotation speed change, "Tef": engine friction torque, "Ta": auxiliary machine torque, "Tα": adjusting torque.

Claims

1. A vehicular drive apparatus comprising:

an engine outputting an engine torque to an output shaft:

an engine operating means operated for variably outputting the engine torque from the engine;
an input shaft which rotates in association with a rotation of a drive wheel of a vehicle;
a clutch provided between the output shaft and the input shaft for controlling a clutch transmitting torque therebetween to be variable;
a clutch operating means for operating the clutch to control the clutch transmitting torque to be variable;
a clutch transmitting torque obtaining means for obtaining the clutch transmitting torque which is generated by the clutch;
a required engine torque calculating means for calculating a required engine torque which corresponds to a required torque of the engine based on an operating amount of the engine operating means;
a start engine torque calculating means for calculating a start engine torque based on the clutch transmitting torque obtained by the transmitting torque obtaining means; and,
an engine control means for controlling the engine to execute a torque-up control so that the engine torque becomes the start engine torque, when a clutch difference rotation speed which is a difference in rotation speed between the input shaft and the output shaft is equal to or more than a predetermined defined

difference rotation speed and at the same time the engine rotation speed is less than a first defined rotation speed and for controlling the engine to execute a normal control so that the engine torque becomes the required engine torque when the clutch difference rotation speed is less than the predetermined defined difference rotation speed.

2. The vehicular drive apparatus according to claim 1, further comprising an engine rotation speed increase necessary torque calculating means for calculating an engine rotation speed increase necessary torque which corresponds to a necessary torque for increasing the engine rotation speed, wherein the start engine toque calculating means calculates the start engine torque based on the engine rotation speed increase necessary torque.

3. The vehicular drive apparatus according to claim 1 or 2, further comprising:

a load obtaining means for obtaining a load acting on the engine; and
a maintaining torque calculating means for calculating a maintaining torque which corresponds to a torque necessary for maintaining the engine rotation speed other than the clutch transmitting torque and the engine rotation speed increase necessary torque based on the load, wherein the start engine torque calculating means calculates the start engine torque based on the maintaining torque.

4. The vehicular drive apparatus according to any one of claims 1 through 3, wherein the engine control means controls the engine so that the engine torque becomes the required engine torque when the required engine torque is larger than the start engine torque.

5. The vehicular drive apparatus according to any one of claims 1 through 4, further comprising:
a corrected start engine torque calculating means for calculating a corrected start engine torque which is more influenced by the required engine torque than the start engine torque, as the engine rotation speed becomes closer to the second defined rotation speed from the first defined rotation speed based on the start engine torque and the required engine torque when the engine rotation speed is equal to or more than the first defined rotation speed and is less than the second defined rotation speed which is faster than the first defined rotation speed and wherein
the engine control means controls the engine to execute a limited torque-up control so that the engine torque becomes the corrected start engine torque when the engine rotation speed is equal to or more than the first defined rotation speed and is less than the second defined rotation speed and controls the engine to execute the normal control when the engine rotation speed is equal to or more than the second defined rotation speed.

6. The vehicular drive apparatus according to any one of claims 1 through 5, further comprising:

a braking force applying means for applying a braking force to the vehicle; and
a braking force operating means for variably controlling the braking force of the braking force applying means, wherein,
the engine control means executes the normal control when the braking force operating means is in operation.

7. The vehicular drive apparatus according to any one of claims 1 through 6, wherein the clutch transmitting torque obtaining means includes a clutch operating amount detecting means for detecting an operating amount of the clutch operating means.

8. The vehicular drive apparatus according to any one of claims 5 through 7, wherein the second defined rotation speed is set so that the second defined rotation speed becomes faster as the operating amount of the engine operating means increases.

9. The vehicular drive apparatus according to any one of claims 2 through 8, wherein the engine rotation speed increase necessary torque is set based on the operating amount of the engine operating means.

10. The vehicular drive apparatus according to any one of claims 1 through 9, further comprising a vehicle speed detecting means for detecting a vehicle speed of a vehicle, wherein the engine control means executes the normal control when the vehicle speed detected by the vehicle speed detecting means is faster than a predetermined defined speed.

FIG. 1

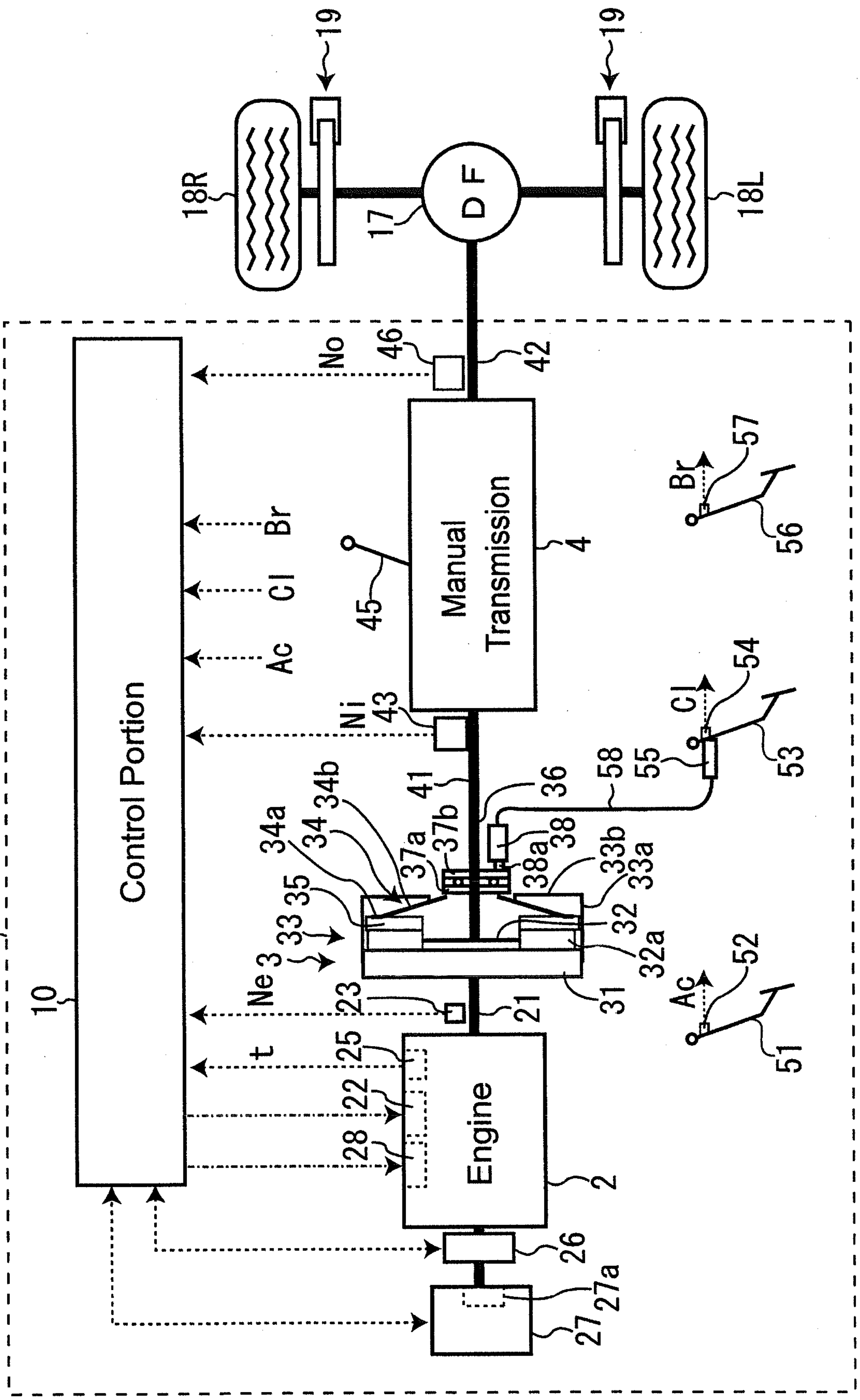

Control Portion
Engine
Manual
Transmission
D F
No
Ni
Ne
Ac
Cl
Br
t
1
2
3
4
10
17
18R
18L
19
21
22
23
25
26
27
27a
28
31
32
32a
33
33a
33b
34
34a
34b
35
36
37a
37b
38
38a
41
42
43
45
46
51
52
53
54
55
56
57
58

FIG. 2

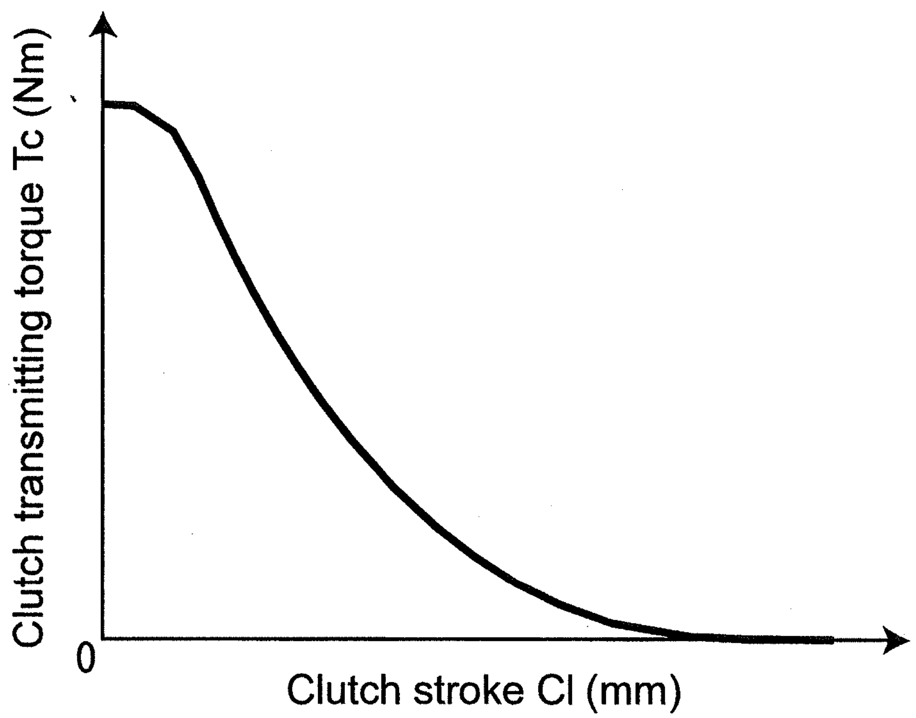
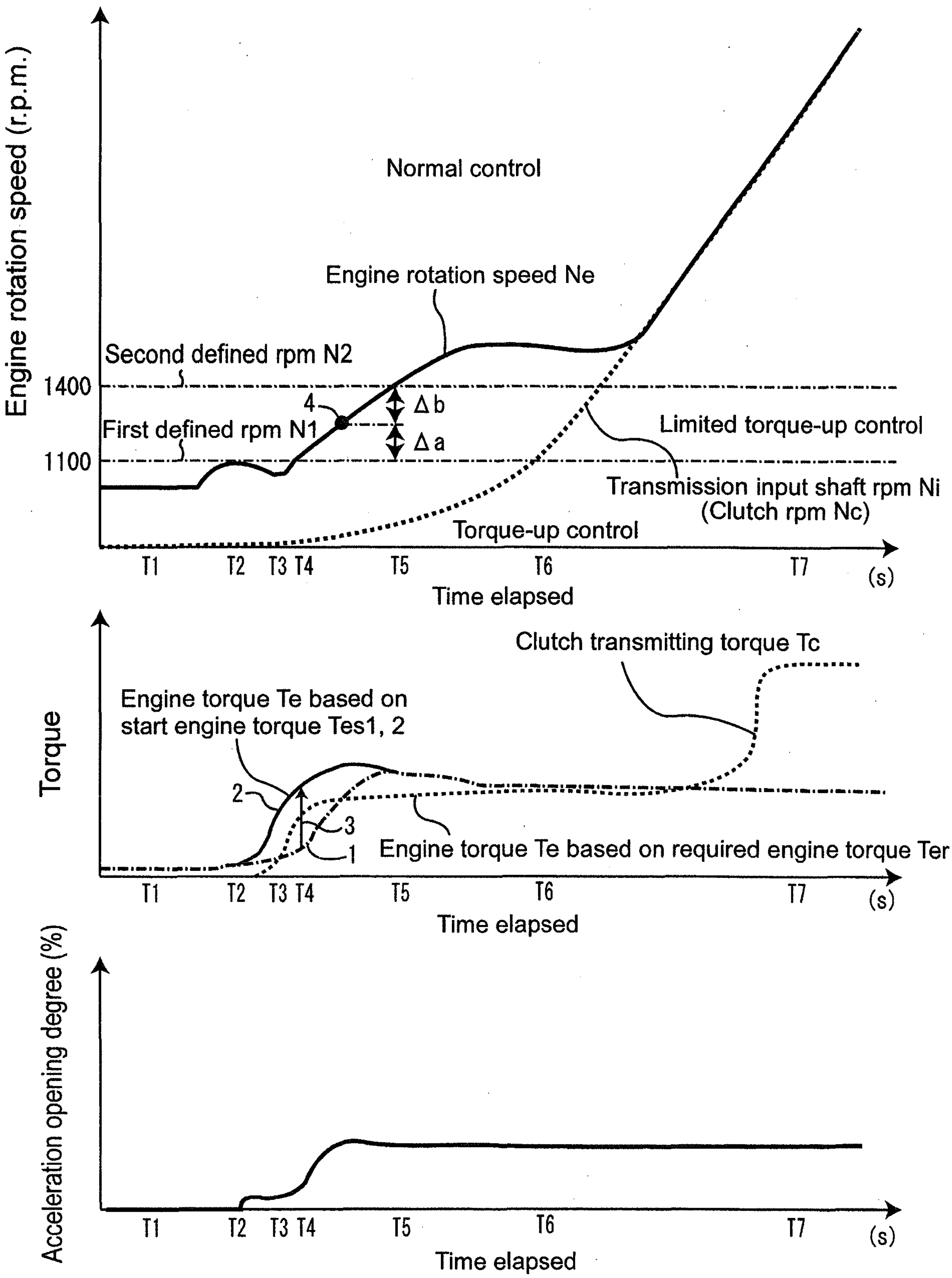


FIG. 3



Engine rotation speed (r.p.m.)
Normal control
Engine rotation speed Ne
Second defined rpm N2
1400
4
Δb
First defined rpm N1
Δa
1100
Limited torque-up control
Transmission input shaft rpm Ni
(Clutch rpm Nc)
Torque-up control
T1
T2
T3
T4
T5
T6
T7
(s)
Time elapsed
Torque
Clutch transmitting torque Tc
Engine torque Te based on
start engine torque Tes1, 2
2
3
1
Engine torque Te based on required engine torque Ter
T1
T2
T3
T4
T5
T6
T7
(s)
Time elapsed
Acceleration opening degree (%)
T1
T2
T3
T4
T5
T6
T7
(s)
Time elapsed

FIG. 4A

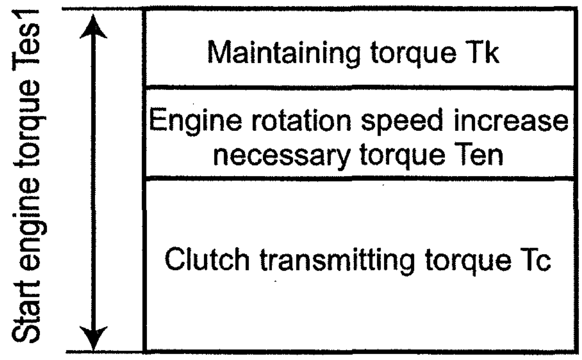

Start engine torque Tes1
Maintaining torque Tk
Engine rotation speed increase necessary torque Ten
Clutch transmitting torque Tc

FIG. 4B

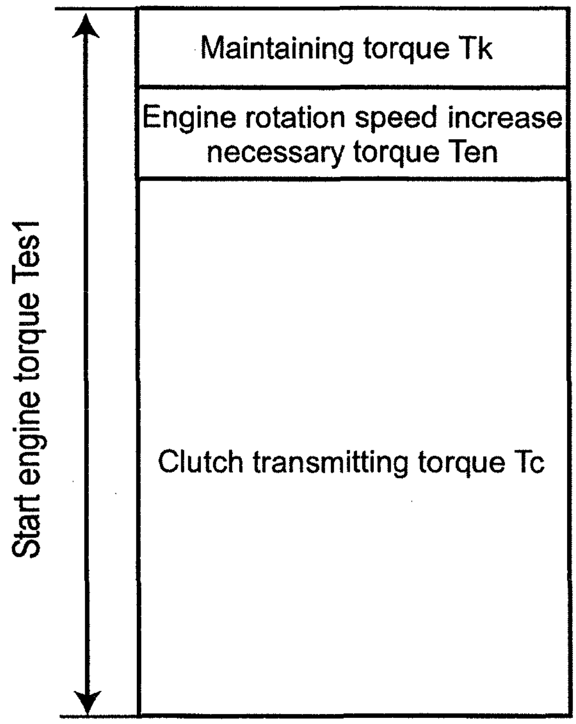

Start engine torque Tes1
Maintaining torque Tk
Engine rotation speed increase necessary torque Ten
Clutch transmitting torque Tc

FIG. 5

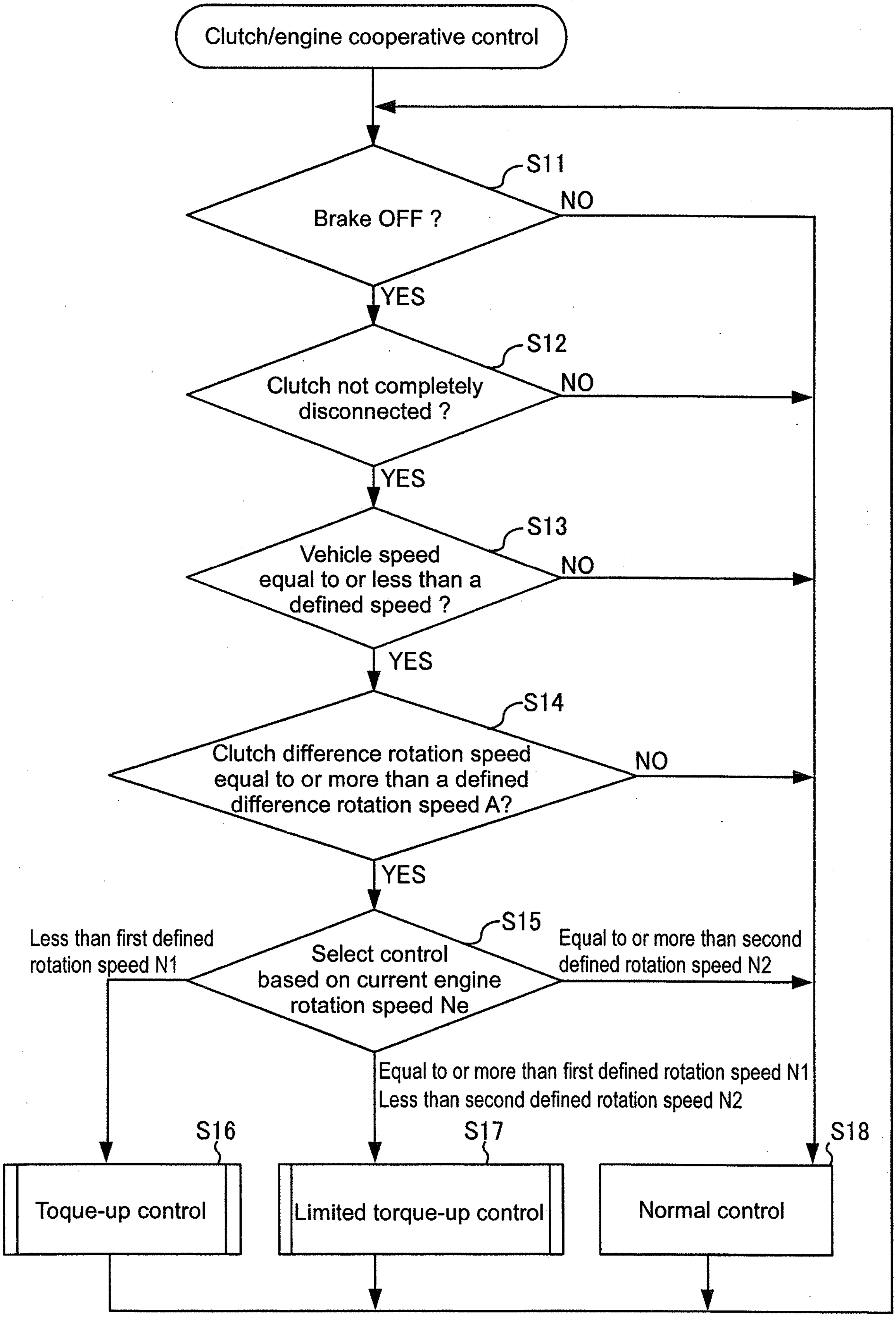

Clutch/engine cooperative control
S11
Brake OFF ?
NO
YES
S12
Clutch not completely disconnected ?
NO
YES
S13
Vehicle speed equal to or less than a defined speed ?
NO
YES
S14
Clutch difference rotation speed equal to or more than a defined difference rotation speed A?
NO
YES
S15
Select control based on current engine rotation speed Ne
Less than first defined rotation speed N1
Equal to or more than second defined rotation speed N2
Equal to or more than first defined rotation speed N1
Less than second defined rotation speed N2
S16
Toque-up control
S17
Limited torque-up control
S18
Normal control

FIG. 6

Second defined rotation speed setting data

Acceleration opening degree (%)	0	25	50	75	100
Second defined rotation speed N2 (r.p.m.)	1400	1400	1550	1700	1850

FIG. 7

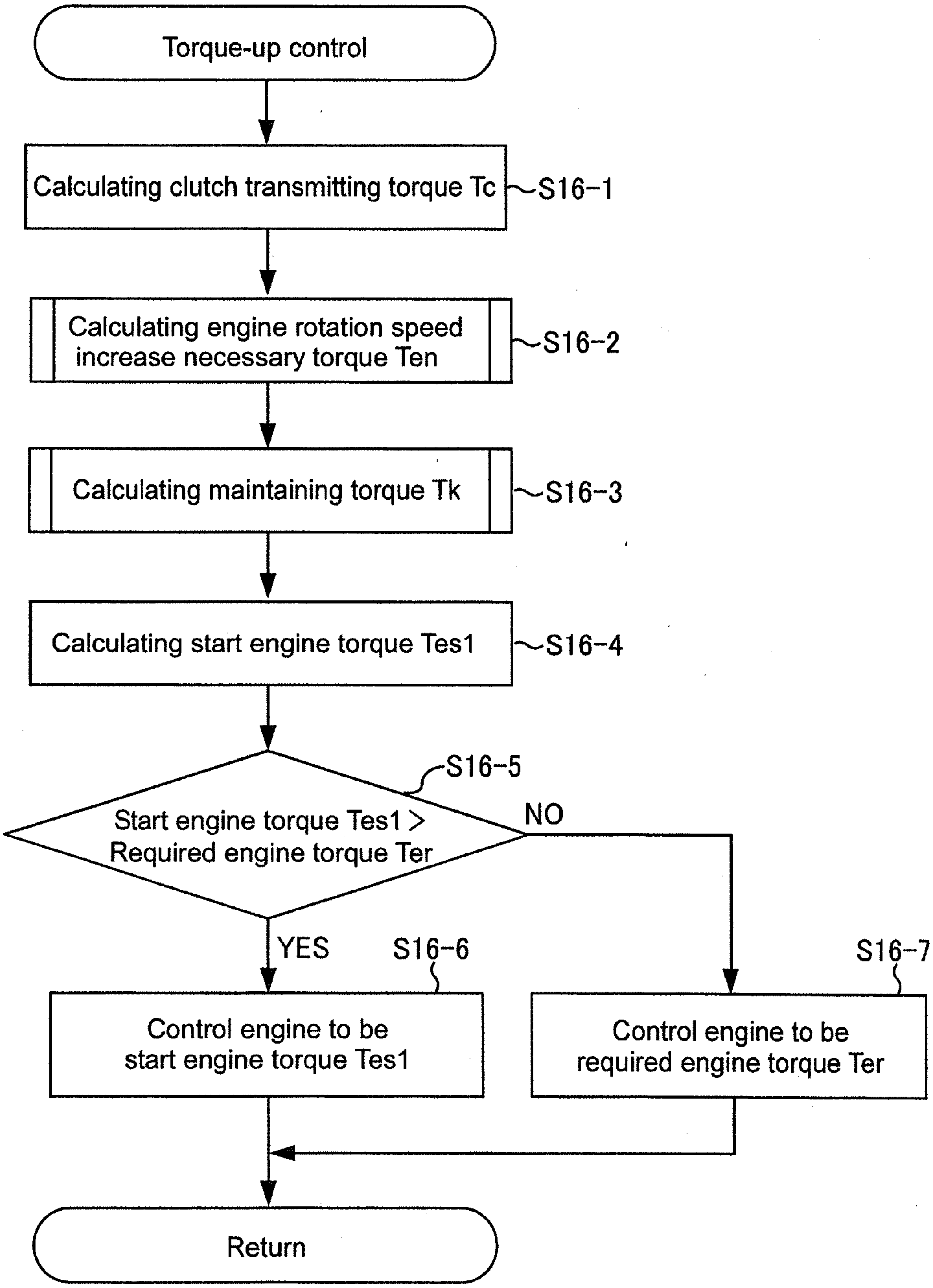

Torque-up control
Calculating clutch transmitting torque Tc
S16-1
Calculating engine rotation speed increase necessary torque Ten
S16-2
Calculating maintaining torque Tk
S16-3
Calculating start engine torque Tes1
S16-4
S16-5
Start engine torque Tes1 > Required engine torque Ter
NO
YES
S16-6
S16-7
Control engine to be start engine torque Tes1
Control engine to be required engine torque Ter
Return

FIG. 8

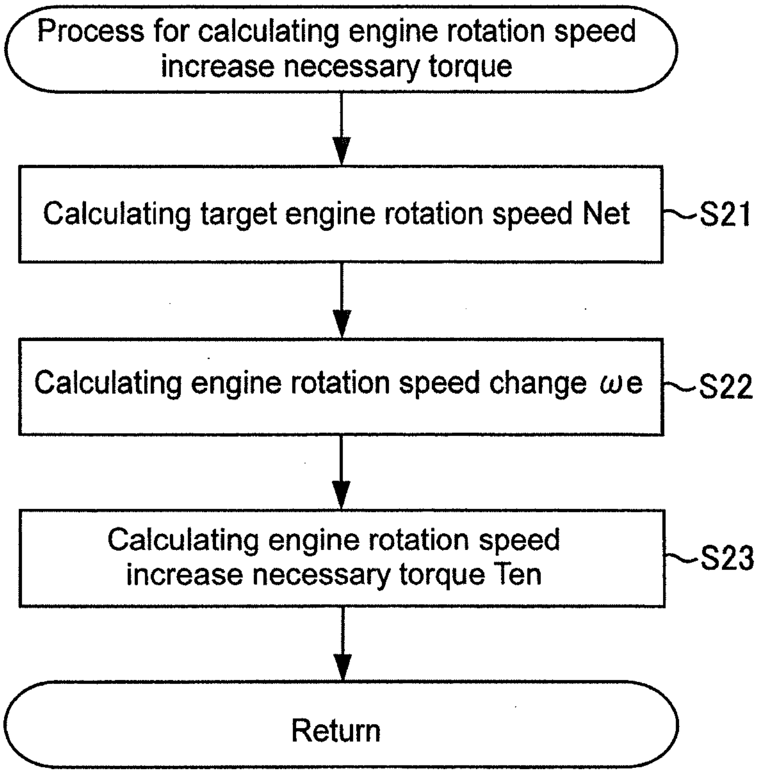

Process for calculating engine rotation speed increase necessary torque
Calculating target engine rotation speed Net
S21
Calculating engine rotation speed change ωe
S22
Calculating engine rotation speed increase necessary torque Ten
S23
Return

FIG. 9

Target engine rotation speed setting data

Acceleration opening degree (%)	0	25	50	75	100
Target engine rotation speed (r.p.m.)	1100	1100	1200	1300	1400

FIG. 10

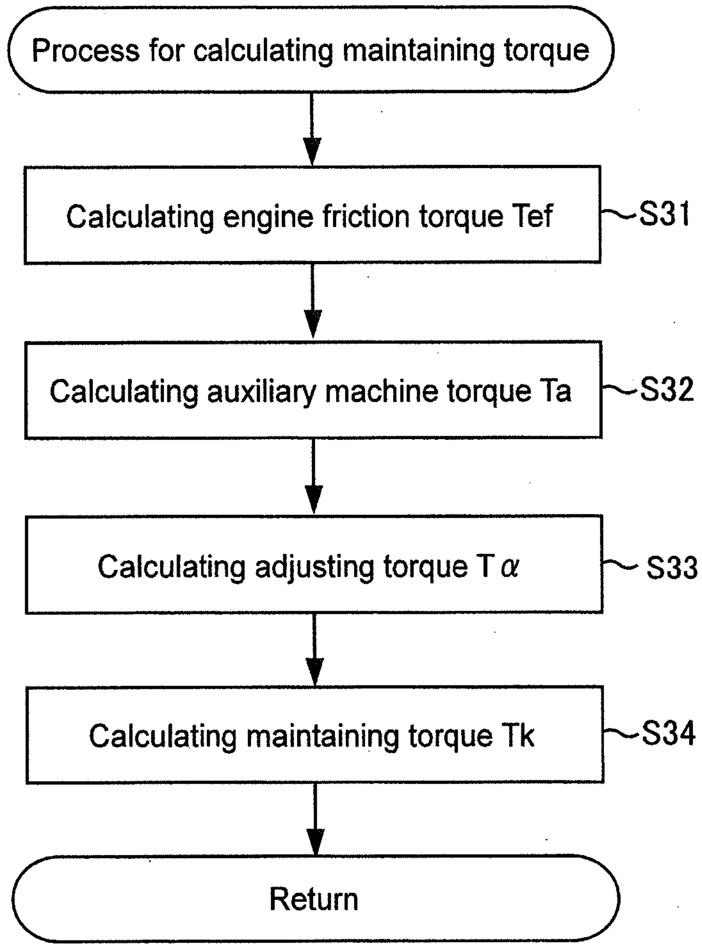

Process for calculating maintaining torque
Calculating engine friction torque Tef
S31
Calculating auxiliary machine torque Ta
S32
Calculating adjusting torque Tα
S33
Calculating maintaining torque Tk
S34
Return

FIG. 11

Compressor auxiliary machine torque calculating data

Engine rotation speed (r.p.m.)	700	1200	1700	2200	2700
Compressor auxiliary machine torque (Nm) (Air conditioner OFF)	5	7	9	10	11
Compressor auxiliary machine torque (Nm) (Air conditioner ON)	13	14	15	16	16

FIG. 12

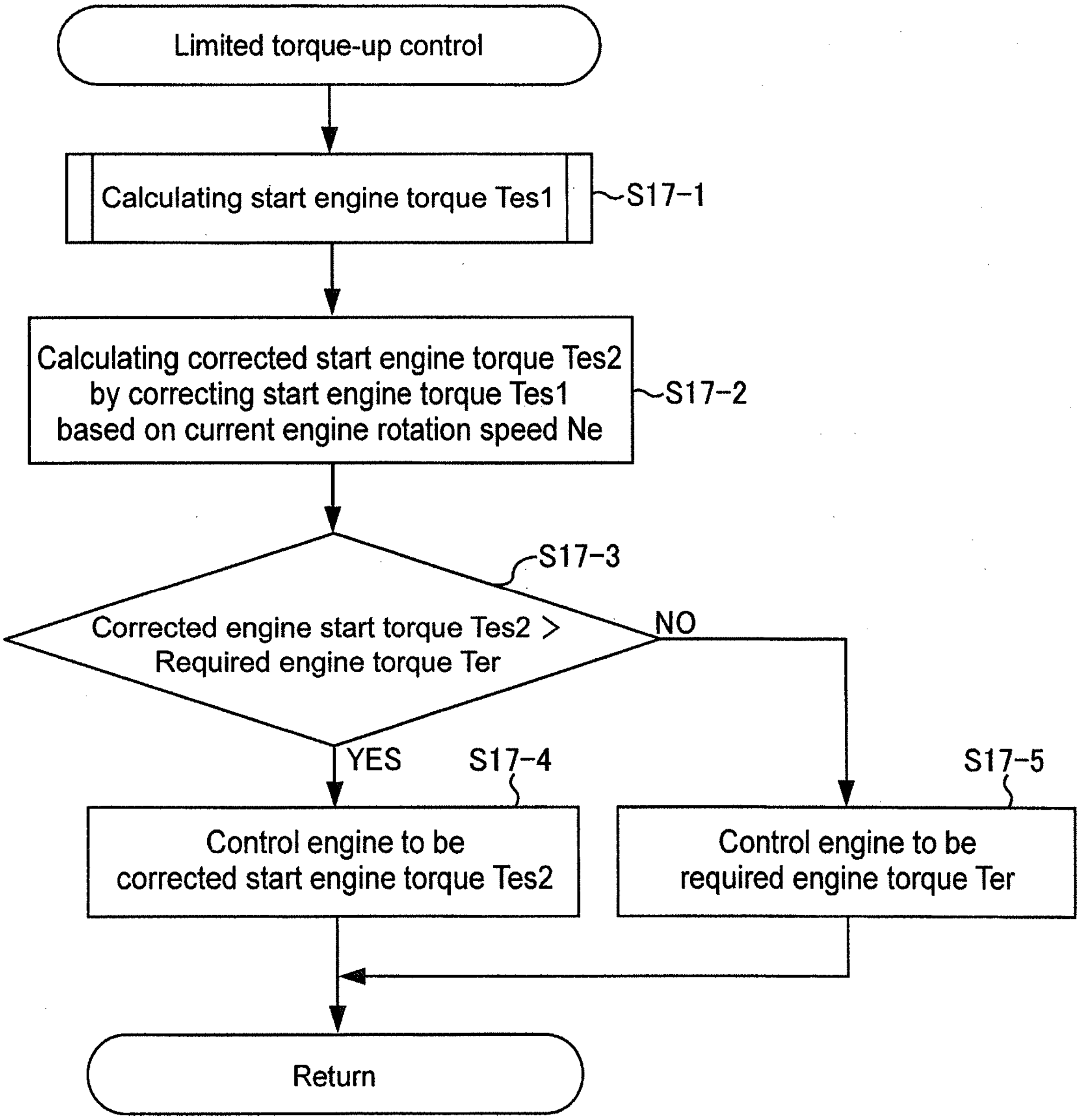

Limited torque-up control
Calculating start engine torque Tes1
S17-1
Calculating corrected start engine torque Tes2
by correcting start engine torque Tes1
based on current engine rotation speed Ne
S17-2
S17-3
Corrected engine start torque Tes2 >
Required engine torque Ter
NO
YES
S17-4
S17-5
Control engine to be
corrected start engine torque Tes2
Control engine to be
required engine torque Ter
Return

FIG. 13

Engine rotation speed increase necessary torque calculating data

Target engine rotation speed Net - current engine rotation speed Ne (r.p.m.)	500	250	0	-250	-500
Engine rotation speed increase necessary torque Net (N)	25	10	0	0	0

FIG. 14

Elapsed time	Vehicle condition	Operation by operator	Various rotation speeds (r.p.m.)	Torque (N)
T1	Vehicle stopping, engine idling Normal engine control	Acceleration: OFF Clutch: Full disconnection Brake: ON	Ne:700 NI:0 Δc:700	Te:0~5 Ter:0 Tes1: × Tc:0
T2	Acceleration ON, brake OFF for preparing for start Normal engine control	Acceleration: ON Clutch: Full disconnection Brake:OFF	Ne:1000 NI:0 Δc:1000	Te:15 Ter:20 Tes1: × Tc:0
T3	Clutch transmitting torque increase by half clutch→Starting Torque-up control Start engine torque Tes1 > Required engine torque Ter Engine controlled by start engine torque Tes1	Acceleration: ON Clutch: Half clutch Brake:OFF	Ne:1050 NI:0 Δc:1050	Te:27 Ter:24 Tes1:30 Tc:10
T4	Engine rotation speed Ne exceeds first defined rotation speed N1 Limited torque-up control Start engine torque Tes2 > Required engine torque Ter Engine controlled by start engine torque Tes2	Acceleration: ON Clutch: Half clutch Brake :OFF	Ne:1120 NI:120 Δc:1000	Te:32 Ter:28 Tes2:35 Tc:25
T5	Engine rotation speed Ne exceeds second defined rotation speed N2 Limited torque-up to normal engine control Engine controlled by required engine torque Ter	Acceleration: ON Clutch: Half clutch Brake :OFF	Ne:1450 NI:250 Δc:1200	Te:40 Ter:42 Tes1: × Tc:35
T6	Maintaining half clutch state Normal engine control Engine controlled by required engine torque Ter	Acceleration: ON Clutch: Half clutch Brake:OFF	Ne:1600 NI:1100 Δc:500	Te:38 Ter:38 Tes1: × Tc:35
T7	Clutch completely engaged Normal engine control Engine controlled by required engine torque Ter	Acceleration: ON Clutch: Full engagement Brake:OFF	Ne:1900 NI:1900 Δc:0	Te:38 Ter:38 Tes1: × Tc:150

Ne:Engine rotation speed
Ni:Transmission input shaft rotation speed
Δc:Clutch difference rotation speed

Te:Engine torque
Ter:Required engine torque
Tes1:Start engine torque (at torque-up control)
Tes2:Corrected start engine torque (at limited torque-up control)
Tc:Clutch transmitting torque

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/075755

A. CLASSIFICATION OF SUBJECT MATTER
F02D41/04(2006.01)i, *F02D29/00*(2006.01)i, *F02D45/00*(2006.01)i

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)
F02D41/00-41/40, F02D29/00-29/02, F02D45/00

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2013
Kokai Jitsuyo Shinan Koho	1971-2013	Toroku Jitsuyo Shinan Koho	1994-2013

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 2007-263135 A (Denso Corp.), 11 October 2007 (11.10.2007), entire text & US 2007/0225115 A1	1-10
A	JP 2006-69267 A (Denso Corp.), 16 March 2006 (16.03.2006), entire text & US 2006/0046896 A1 & US 2008/0207394 A1	1-10
A	JP 2001-263138 A (Suzuki Motor Corp.), 26 September 2001 (26.09.2001), entire text (Family: none)	1-10

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

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Date of the actual completion of the international search	Date of mailing of the international search report
24 December, 2013 (24.12.13)	07 January, 2014 (07.01.14)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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Patent documents cited in the description

- JP 2001263138 A **[0004]**
- JP 2008157184 A **[0145]**