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Control method of a power transmission device
Steuerverfahren einer Kraftübertragungsvorrichtung
Procédé de contrôle pour dispositif de transmission de puissance

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Description

[0001] The present invention relates to a control method of a power transmission device of an internal combustion engine.

[0002] In a power transmission device which transmits a rotational power of a crankshaft of an internal combustion engine to an output side by way of a clutch mechanism and a speed change mechanism, the internal combustion engine is started by a starter in a state that the clutch mechanism is in a disengaged state, and the internal combustion engine assumes an idling state at a steady-state idling rotational speed.

[0003] Here, cranking is also finished.

[0004] In such an idling state, the speed change mechanism is changed over from a neutral state to a first speed gear, and the clutch mechanism is brought into an engaged state thus transmitting the power to the output side of the speed change mechanism.

[0005] In the idling state of the internal combustion engine, the clutch mechanism is in a disengaged state. However, when a clutch input side of the clutch mechanism is rotated due to the rotation of the crankshaft, a clutch output side of the clutch mechanism is rotated together with the clutch input side by friction and, further, a speed change drive side of the speed change mechanism which is continuously connected with the clutch output side is rotated and hence, when the speed change mechanism is changed over from the neutral state to a first speed gear from the neutral state, a speed change driven side which is not rotated is momentarily engaged with the rotating clutch output side and the speed change drive side which are rotated due to a rotational inertia thus generating impacts and noises.

[0006] Here, various kinds of techniques have been proposed for preventing the generation of impacts and noises (for example, see JP 3509243).

[0007] Document EP 1 544 513 A shows the features of the preamble of claims 1 and 8.

[0008] A power transmission device disclosed in the JP 3509243 includes a brake mechanism which performs braking by bringing a brake shoe into contact with a clutch outer (clutch output side) of a start clutch only when a speed change mechanism is changed over from a neutral state to a first speed gear and hence, the number of parts is increased and the surrounding of the clutch mechanism becomes complicated thus increasing a cost.

[0011] The invention has been made under such circumstances and it is an object of the invention to provide a control method of a power transmission device which requires no braking mechanism at a low cost and can prevent the generation of impacts and noises when a speed change mechanism is changed over from a neutral state to a first speed gear.

[0012] To achieve the above-mentioned object, the invention described in claim 1 is characterized in that, in a control method of a power transmission device for controlling a power transmission device which transmits a rotational power of a crankshaft of an internal combustion engine to an output side by way of a clutch mechanism and a speed change mechanism, the speed change mechanism is automatically changed over from a neutral state to a first speed gear during a period from a point of time at which an ignition switch is turned on to a point of time at which an engine rotational speed arrives at a steady-state idling rotational speed due to starting of an internal combustion engine.

[0013] Hence, when the rotation of the crankshaft rotates the clutch input side of the clutch mechanism, in spite of the disengagement of the clutch mechanism, the rotation of the crankshaft rotates the clutch output side together with the clutch input side and, further, even when the speed change drive side of the speed change mechanism is rotated, the engine rotational speed does not arrive at a steady-state idling rotational speed in changing over the speed change mechanism to the first speed gear from the neutral state and hence, the rotational speed of the clutch output side is small whereby the impacts and noises which are generated along with the changeover of the speed change mechanism from the neutral state to the first speed gear can be decreased.

[0014] By making the mechanism for braking the clutch output side which is rotated together with the clutch input side unnecessary, it is possible to simplify the structure of the speed change mechanism and to miniaturize the internal combustion engine and to reduce a manufacturing cost.

[0015] According to The present invention, the speed change mechanism is automatically changed over from the neutral state to the first speed gear at the point of time at which the engine rotational speed arrives at the predetermined low-rotational speed lower than the idling rotational speed by turning on the starter switch. Hence, it is possible to adjust a degree of suppressing impacts and noises which are generated along with the changeover of the speed change mechanism from the neutral state to the first speed gear.

[0016] Preferably, the predetermined rotational speed is set to an extend that impact sounds are generated that can be noticed by the rider.

[0017] Accordingly, but not claimed even when the
speed change mechanism is changed over from the neutral state to the first speed gear before and after the point of time that the starter switch is turned on during the period from the point of time at which the ignition switch is turned on to the point of time at which the engine rotational speed arrives at the steady-state idling rotational speed due to starting of the internal combustion engine, the rotational speed of the clutch output side which is rotated together with the clutch input side can be set to 0 or a small value and hence, the impacts and noises which are generated along with the changeover of the speed change mechanism from the neutral state to the first speed gear can be decreased.

Further, to achieve the above-mentioned object, another invention, which is not claimed refers to a control method of a power transmission device for controlling a power transmission device which transmits a rotational power of a crankshaft of an internal combustion engine to an output side by way of a clutch mechanism and a speed change mechanism, characterized in that, the speed change mechanism is automatically changed over from a neutral state to a first speed gear at a point of time at which an ignition switch is turned on.

By performing the control such that the speed change mechanism is changed over from the neutral state to the first speed gear at the point of time at which the ignition switch is turned on, the speed change mechanism is changed over from the neutral state to the first speed gear in a state that the crankshaft is stopped and hence, there is no possibility that impacts and noises are generated along with the changeover of the speed change mechanism.

The following features can preferably be applied in a power transmission device according to the first invention or according to the second invention.

Preferably, a lamp is turned on in the starting ready state. Further, the control method should perform after the changeover from neutral state to the first speed gear a change over the first speed gear to the neutral state and then again the changeover from the neutral state to the first speed gear and that the repetition of the changeover generates operation sounds. Preferably, the speed change mechanism is a constant-mesh speed change gear mechanism. Furthermore, the power transmission device should comprise an electronic control unit which controls the speed change mechanism and the clutch mechanism via oil pressure control means.

Another aspect of the present invention is a power transmission device which transmits a rotational power of a crankshaft of an internal combustion engine to an output side by way of a clutch mechanism and a speed change mechanism and which is further characterized in that, the power transmission device is further adopted to automatically change over the speed change mechanism from the neutral state to the first gear at a certain point of time so that the generation of impacts and noises due to the change over of the speed change mechanism is minimized.

Said power transmission device is further characterized in that, the speed change mechanism is automatically changed over from the neutral state to the first speed gear at a point of time at which the engine rotational speed arrives at a predetermined low-rotational speed lower than the idling rotational speed by turning on a starter switch. In an alternative not claimed embodiment, the speed change mechanism is automatically changed over from the neutral state to the first speed gear at a point of time at which a predetermined time elapses after turning on the ignition switch.

Another not claimed option is that the speed change mechanism is automatically changed over from a neutral state to a first speed gear at a point of time at which an ignition switch is turned on.

Preferably, the speed change mechanism is a constant-mesh speed change gear mechanism.

Preferably, the power transmission device comprises an electronic control unit which controls the speed change mechanism and the clutch mechanism via oil pressure control means.

These and other objects of the present invention will become more apparent upon consideration of the following detailed description of preferred embodiments thereof, when taken in conjunction with the attached drawings, in which:

- [Fig. 1] is a cross-sectional view showing an essential part of an internal combustion engine in which a power transmission device according to one embodiment of the invention is incorporated.
- [Fig. 2] is a cross-sectional view of the power transmission device.
- [Fig. 3] is a schematic block diagram of a speed change control.
- [Fig. 4] is a control flowchart of the speed change control.
- [Fig. 5] is a graph showing a crankshaft rotational speed and a main shaft rotational speed when the internal combustion engine is started using a control method of the power transmission device of the invention.
- [Fig. 6] is a flowchart of a control method of another power transmission device.
- [Fig. 7] is a graph showing the control method.
- [Fig. 8] is a flowchart of a control method of a still another power transmission device.
- [Fig. 9] is a graph showing the control method.

Hereinafter, one embodiment according to the invention is explained in conjunction with Fig. 1 to Fig. 5.

A vehicle-use power transmission device 10 according to this embodiment is a power transmission device which is assembled in a 4-cylinder 4-stroke internal combustion engine E mounted on a motorcycle, and Fig. 1 is a cross-sectional view of an essential part of the power transmission device 10.
[0030] The internal combustion engine E is mounted on a vehicle with a crankshaft 2 thereof directed in the lateral direction. The crankshaft 2 is pivotally and rotatably mounted on a crankcase 1. An AC generator 3 is mounted on a left end portion of the crankshaft 2 which projects leftwardly from the crankcase 1. A valve-dribe-system chain sprocket wheel 4, an engine-start-system driven gear 5 and a one-way clutch 6 are mounted on a right end portion of the crankshaft 2 which projects rightwardly from the crankcase 1.

[0031] The engine-start-system driven gear 5 constitutes a final gear of a speed reduction gear mechanism which transmits driving of a starter motor not shown in the drawing, and the driving of the starter motor is transmitted to the crankshaft 2 by way of the speed reduction gear mechanism and the one-way clutch 6 and forcibly rotates the crankshaft 2 thus starting the internal combustion engine E.

[0032] A rear side of the crankcase 1 has a lateral width thereof narrowed thus forming a transmission case 11. A main shaft 20 and a counter shaft 51 which are directed in the lateral direction of the transmission case 11 are respectively and pivotally and rotatably supported on the transmission case 11 by way of bearings 21, 52.

[0033] The main shaft 20 is constituted of an inner sleeve 20i and an outer sleeve 20o which is rotatably fitted on a portion of the inner sleeve 20i. A left end of the inner sleeve 20i is pivotally and rotatably mounted in a bearing opening which is formed in a left side wall 11l of the transmission case 11 by way of the bearing 21. The outer sleeve 20o is relatively rotatably fitted on a substantially center position of the inner sleeve 20i. A portion of the outer sleeve 20o is pivotally and rotatably supported in a bearing opening which is formed in a right side wall 11r of the transmission case 11 by way of the bearing 21. In this manner, the outer sleeve 20o is supported together with the inner sleeve 20i.

[0034] A cylindrical collar 22 is fitted on a portion of an outer periphery of an outside portion of the outer sleeve 20o which projects rightwardly from the right bearing 21 and is brought into contact with the right bearing 21, and a primary driven gear 23 is pivotally and rotatably supported on the cylindrical collar 22.

[0035] On the other hand, a primary drive gear 23a is formed on one crank web of the crankshaft 2 which corresponds to the primary driven gear 23b, and the primary drive gear 23a and the primary driven gear 23b are meshed with each other.

[0036] A twin clutch 25 is mounted on the inner sleeve 20i and the outer sleeve 20o on a right side of the primary driven gear 23b.

[0037] The twin clutch 25 is constituted of a pair of first clutch 26 and second clutch 27, and the first clutch 26 and the second clutch 27 are formed of hydraulic multi-plate friction clutches of the same structure which include a common clutch housing 28.

[0038] The clutch housing 28 is formed of a bowl-shaped member which constitutes a common outer peripheral portion of the first clutch 26 and a second clutch 27 which are arranged in parallel in the axially lateral direction, and the clutch housing 28 has a right side thereof opened and has a left-side bottom portion thereof mounted on the primary driven gear 23b by way of a torsion spring 24.

[0039] The left-side first clutch 26 is configured such that a clutch boss 26b is engaged with the outer sleeve 20o by spline fitting and a pressure plate 26p is slidably supported on the clutch boss 26b in the axial direction, and an oil pressure receiving plate 26q is supported on a back side of the pressure plate 26p.

[0040] A compression spring 26s is interposed between the pressure plate 26p and the clutch boss 26b.

[0041] Between outer peripheral portions of the clutch boss 26b and the pressure plate 26p, friction discs which are slidably fitted in the clutch housing 28 in the axial direction and clutch discs which are slidably fitted on the clutch boss 26b in the axial direction are arranged alternately.

[0042] The right-side second clutch 27 is configured such that a clutch boss 27b is engaged with a portion of the inner sleeve 20i which projects rightwardly from the outer sleeve 20o by spline fitting, a pressure plate 27p is slidably supported on the clutch boss 27b in the axial direction, and an oil pressure receiving plate 27q is supported on a back side of the pressure plate 27p. A compression spring 27s is interposed between the pressure plate 27b and the clutch box 27b.

[0043] Between outer peripheral portions of the clutch boss 27b and the pressure plate 27p, friction discs which are slidably fitted in the clutch housing 28 in the axial direction and clutch discs which are slidably fitted on the clutch boss 27b in the axial direction are arranged alternately.

[0044] In the inner sleeve 20i, a lubricant passage 30 is formed along an axis of the inner sleeve 20i from a left end of the inner sleeve 20i to a position where the first clutch 26 is arranged and a shaft hole 31 is formed along the axis from a right end of the inner sleeve 20i to a position where the first clutch 26 is arranged. In the shaft hole 31, a duplicate tube which is constituted of an inner conduit 32 and an outer conduit 33 are inserted from the right end of the inner sleeve 20i.

[0045] The inner conduit 32 arrives at a position of the first clutch 26 in the vicinity of a left end of the shaft hole 31, and the outer conduit 33 arrives at a position of the second clutch 27.

[0046] A seal member 34 is interposed between an outer periphery of the inner conduit 32 in the vicinity of a left end of the inner conduit 32 and the shaft hole 31, a left end space of the shaft hole 31 which is defined by the seal member 34 is communicated with a first control oil passage 41 formed in the inside of the inner conduit 32 and, at the same time, an oil passage 41a is formed in the inner sleeve 20i, the outer sleeve 20o and a sleeve portion of the clutch boss 26b in a penetrating manner toward a gap defined between the pressure plate 26p...
and the oil pressure receiving plate 26s of the first clutch 26 from the left end space of the shaft hole 31.

[0047] Here, the space defined between the pressure plate 26p and the clutch boss 26b is communicated with the lubricant passage 30 by way of the oil passage 30a.

[0048] Accordingly, when an oil pressure is applied to a first control oil passage 41 which is arranged inside the inner conduit 32, a pressured oil is supplied to the space defined between the pressure plate 26p and the oil pressure receiving plate 26s of the first clutch 26 by way of the oil passage 41 and the left end space of the shaft hole 31, and the pressure plate 26p is pushed against a biasing force of the compression spring 26s. Accordingly, the first clutch 26 is engaged with the clutch housing 28 due to the increase of the friction between the friction discs and the clutch discs and hence, the rotation of the clutch housing 28 is transmitted to the outer sleeve 20o of the main shaft 20.

[0049] When the oil pressure which is applied to the first control oil passage 41 is released, due to the oil pressure of the lubricant which passes through the lubricant passage 30 and the oil passage 30a and the compression spring 26s, the pressure plate 26p returns to an original position and hence, the first clutch 26 is disengaged.

[0050] Further, a seal member 35 is interposed between an outer periphery of the outer conduit 33 in the vicinity of a left end of the outer conduit 33 which arrives at a position of the second clutch 27 and the shaft hole 31. A second control oil passage 42 is formed between an outer periphery of the outer conduit 33 on a right side of the seal member 35 and an inner periphery of the shaft hole 31. An oil passage 42a is formed in the inner sleeve 20i and a cylindrical portion of the clutch boss 27b in a penetrating manner from the second control oil passage 42 to a gap defined between the pressure plate 27p and the oil receiving plate 27s of the second clutch 27.

[0051] Here, a lubricant passage 43 defined between the outer periphery of the inner conduit 32 on a left side of the seal member 35 and the inner periphery of the outer conduit 33 is communicated with a space formed on a left side of the seal member 35, and the space formed on the left side of the seal member 35 is communicated with a space defined between the pressure plate 27p and the clutch boss 27b by way of an oil passage 43a.

[0052] Accordingly, when an oil pressure is applied to the second control oil passage 42 which is arranged outside of the outer conduit 33, a pressured oil is supplied to the space defined between the pressure plate 27p and the oil pressure receiving plate 27s of the second clutch 27 by way of the oil passage 42a, and the pressure plate 27p is pushed against a biasing force of the compression spring 27s. Accordingly, the second clutch 27 is engaged with the clutch housing 28 due to the increase of the friction between the friction disc and the clutch disc and hence, the rotation of the clutch housing 28 is transmitted to the inner sleeve 20i of the main shaft 20.

[0053] When the oil pressure which is applied to the second control oil passage 42 is released, due to the oil pressure of the lubricant which passes through the lubricant passage 43 and the oil passage 43a and the compression spring 27s, the pressure plate 27p returns to an original position and the second clutch 27 is disengaged.

[0054] In a shaft support portion 55a of a right case cover 55 which pivotally supports end portions of the inner conduit 33 and the outer conduit 33 which project from a right end of the inner sleeve 20i, hydraulic chambers 41b, 42b which are respectively communicated with the first control oil passage 41 and the second control oil passage 42 are formed, and controlled oil pressures are applied to the hydraulic chambers 41b, 42b by an oil pressure control means thus controlling the engagement and disengagement of the respective first clutch 26 and second clutch 27.

[0055] In the inside of the above-mentioned transmission case 11 into which the main shaft 20 to which the power of the twin clutch 25 is transmitted is inserted, a speed change gear mechanism 50 is provided between the main shaft 20 and a counter shaft 51.

[0056] The outer sleeve 20o of the main shaft 20 covers a right half portion of the inner sleeve 20i in the inside of the transmission case 11. With respect to the inner sleeve 20i which projects leftwardly from the outer sleeve 20o, a first speed change drive gear m1 is integrally formed on the inner sleeve 20i close to the left-side bearing 21, and a fifth speed change drive idle gear m5 is pivotally mounted on the inner sleeve 20i in a state that the fifth speed change drive idle gear m5 is arranged on a right side of the first speed change drive gear m1, and a third speed change drive shift gear m3 is engaged with the inner sleeve 20i by spline fitting in an axially slidable manner between a right side of the fifth speed change drive idle gear m5 and a left end of the outer cylinder 20o.

[0057] When the third speed change drive shift gear m3 is shifted leftwardly from a neutral position, the third speed change drive shift gear m3 is connected to the fifth speed change drive idle gear m5.

[0058] With respect to the outer sleeve 20o arranged in the inside of the transmission case 11, a second speed change drive gear m2 is integrally formed on the outer sleeve 20o close to the right-side bearing 21, and a sixth speed change drive idle gear m6 is pivotally and rotatably supported on the outer sleeve 20o on a left side of the second speed change drive gear m2, and a fourth speed change drive shift gear m4 is engaged with the outer sleeve 20o by spline fitting in an axially slidable manner between a left side of the sixth speed change drive idle gear m6 and a left end of the outer cylinder 20o.

[0059] When the fourth speed change drive shift gear m4 is shifted rightwardly from a neutral position, the fourth speed change drive shift gear m4 is connected to the sixth speed change drive idle gear m6.

[0060] On the other hand, with respect to the counter shaft 51, a first speed change driven idle gear n1 is pivotally and rotatably supported on the counter shaft 51 close to the left-side bearing 52, and the first speed change driven idle gear n1 is meshed with the first speed
change speed change drive shift gear n5 is engaged with the counter shaft 51 by spline fitting in an axially slidable manner on a right side of the first speed change driven idle gear n1, and the fifth speed change driven shift gear n5 is meshed with the fifth speed change drive idle gear m5. Further, a third speed change driven idle gear n3 is pivotally and rotatably supported on the counter shaft 51 on a right side of the fifth speed change driven shift gear n5.

[0061] When the fifth speed change driven shift gear n5 is shifted leftwardly from a neutral position, the fifth speed change driven shift gear n5 is connected to the first speed change driven idle gear n1, while when the fifth speed change driven shift gear n5 is shifted rightwardly from a neutral position, the fifth speed change driven shift gear n5 is connected to the third speed change driven idle gear n3.

[0062] Further, with respect to a right half portion of the counter shaft 51, a second speed change driven idle gear n2 is rotatably and pivotally mounted close to the right-side bearing 52 and is meshed with the second speed change drive gear m2, a sixth speed change driven shift gear n6 is engaged with the counter shaft 51 by spline fitting in an axially slidable manner on a left side of the second speed change driven idle gear n2 and is meshed with the sixth speed change drive idle gear m6, and a fourth speed change driven idle gear n4 is pivotally and rotatably supported on a left side of the sixth speed change driven shift gear n6 and is meshed with the fourth speed change drive shift gear m4.

[0063] When the sixth speed change driven shift gear n6 is shifted rightwardly from a neutral position, the sixth speed change driven shift gear n6 is connected to the second speed change driven idle gear n2, while when the sixth speed change driven shift gear n6 is shifted leftwardly, the sixth speed change driven shift gear n6 is connected to the fourth speed change driven idle gear n4.

[0064] As described heretofore, the speed change gear mechanism 50 of this embodiment is a constant-mesh speed change gear mechanism. By shifting four shift gears, that is, by shifting the third speed change drive shift gear m3 and the fourth speed change drive shift gear m4 which are mounted on the main shaft 20 and the fifth speed change driven shift gear n5 and the sixth speed change driven shift gear n6 which are mounted on the counter shaft 51 using four shift forks 64a, 64b, 64c, 64d of the speed change drive mechanism 60, the changeover of the speed change gear can be performed.

[0065] The speed change drive mechanism 60 is configured such that a shift drum 61 which is directed in the lateral direction is pivotally and rotatably supported on the transmission case 11, guide shafts 62, 63 extend over the speed change drive mechanism 60 in a state that the guide shafts 62, 63 are arranged close to the shift drum 61, shift forks 64a, 64b which are pivotally mounted on the guide shaft 62 arranged close to the main shaft 20 in an axially slidable manner are engaged with the third speed change drive shift gear m3 and the fourth speed change drive shift gear m4 which are mounted on the main shaft 20 and, at the same time, respective shift pins of the shift forks 64a, 64b are fitted in respective shift grooves which are formed in an outer peripheral surface of the shift drum 61.

[0066] Further, shift fork 64c, 64d which are pivotally mounted on the guide shaft 63 and are arranged close to the counter shaft 51 in an axially slidable manner are engaged with the fifth speed change driven shift gear m5 and the sixth speed change driven shift gear n6 which are mounted on the counter shaft 51 and, at the same time, respective shift pins of the shift forks 64c, 64d are fitted in respective shift grooves which are formed in the outer peripheral surface of the shift drum 61.

[0067] The shift drum 61 is rotated by driving of a speed change motor 65 by way of a gear mechanism 66 and four shift forks 64a, 64b, 64c, 64d which are fitted in four shift grooves respectively perform predetermined movements depending on a rotational angle of the shift drum 61 so as to change over the speed change gears of the speed change gear mechanism 50.

[0068] Fig. 1 and Fig. 2 show the speed change gear mechanism 50 in a neutral state in which either one of gears which are meshed with each other is in an idling state and hence, the rotation of the main shaft 20 is not transmitted to the counter shaft 51.

[0069] When the shift drum 61 is rotated by a predetermined angle and the shift fork 64c shifts the fifth speed change drive shift gear n5 leftwardly and brings the fifth speed change drive shift gear n5 into contact with the first speed change driven idle gear n1 from the above-mentioned neutral state, power is transmitted to the counter shaft 51 from the inner sleeve 20i by way of the first speed change drive gear m1, the first speed change driven idle gear n1, and the fifth speed change driven shift gear n5 thus constituting a first speed gear.

[0070] In the same manner as the first speed gear, a second speed change driven shift gear n6 rightwardly, a third speed gear is constituted by shifting the sixth speed change driven shift gear n6 rightwardly, a third speed gear is constituted by shifting the fifth speed change drive shift gear m5 rightwardly, a fourth speed gear is constituted by shifting the sixth speed change driven shift gear n6 leftwardly, a fifth speed gear is constituted by shifting the third speed change drive shift gear m3 leftwardly, and a sixth speed gear is constituted by shifting the fourth speed change drive shift gear m4 rightwardly.

[0071] The counter shaft 51 on which the speed change driven gears are pivotally mounted constitutes an output shaft, and an output sprocket wheel 53 is fitted on a left end portion of the counter shaft 51 which projects further leftwardly from the left-side bearing 52.

[0072] A drive chain 54 extends between the output sprocket wheel 53 and the rear drive wheel-side driven sprocket wheel, and the power is transmitted to the rear drive wheel thus allowing the motorcycle to travel.

[0073] In the above-mentioned power transmission device 10 which transmits the rotational power of the crankshaft 2 of the internal combustion engine E to the output
Fig. 3 is a schematic block diagram of a speed control system of an internal combustion engine E.

Fig. 4 shows a control flowchart of the speed control system of the internal combustion engine E. The control system includes a speed change control performed by an ECU 70, a speed change drive mechanism 60 which drives the speed change drive motor 65, and a clutch oil pressure control means.

Detection signals are inputted to the ECU 70 from a speed change position sensor 71 and an engine speed sensor 72. The ECU 70 outputs drive signals to the speed change drive mechanism 60 and a clutch oil pressure control means.

A control method of the power transmission device 10 when the internal combustion engine E is started by the ECU of the invention is explained in accordance with a control flowchart shown in Fig. 4 and a graph shown in Fig. 5.

First of all, it is determined whether the ignition switch 73 is turned on or not (Step 1). If it is determined that the ignition switch 73 is turned on, the control system advances to Step 2 in which it is determined whether the power transmission device 10 is in a neutral state or not (Step 2). If the power transmission device 10 is in the neutral state, processing leaves this routine, while if it is determined that the power transmission device 10 is not in the neutral state, the control system advances to Step 3 in which it is determined whether an engine rotational speed Nc exceeds a predetermined low rotational speed N1 or not.

If it is determined that the engine rotational speed Nc exceeds the predetermined low rotational speed N1, the control system advances to Step 4 in which the speed change control is performed.

The graph shown in Fig. 5 is rectangular coordinates, where the time t is taken on an axis of abscissa and a rotational speed is taken on an axis of ordinates. A polygonal line depicted by a chain line indicates a speed change driven idle gear n1, while a polygonal line depicted by a solid line indicates a speed change driven shift gear n5. A graph shown in Fig. 5 is used to explain the control system.

The crankshaft rotational speed Nc is increased due to driving of the starter motor, and the internal combustion engine E is started from a point of time Ti and hence, the crankshaft rotational speed Nc arrives at an idling rotational speed Nid. The crankshaft rotational speed Nc is maintained to the idling rotational speed Nid.

As shown in Fig. 5, the main shaft rotational speed Nm is increased with a co-rotation rotational speed lower than the crankshaft rotational speed Nc along with the increase of the crankshaft rotational speed Nc.

Further, until the crankshaft rotational speed Nc arrives at the idling rotational speed Nid, at a point of time T1 at which the crankshaft rotational speed Nc arrives at a predetermined low rotational speed N1 considerably lower than the idling rotational speed Nid, by driving the speed change motor 65 of the speed change drive mechanism 60, the fifth speed change driven shift gear n5 is shifted leftwardly using the shift fork 64c to connect the fifth speed change driven shift gear n5 and the first speed change driven idle gear n1 such that the rotation of the crankshaft is increased due to driving of the starter motor, and the internal combustion engine E is started from a point of time Ti and hence, the crankshaft rotational speed Nc arrives at an idling rotational speed Nid.

In such a period, the rotation of the crankshaft is increased due to driving of the starter motor, and the internal combustion engine E is started from a point of time Ti and hence, the crankshaft rotational speed Nc arrives at an idling rotational speed Nid. The crankshaft rotational speed Nc is maintained to the idling rotational speed Nid and hence, the internal combustion engine E is warmed up.

In such a period, the rotation of the crankshaft is increased due to driving of the starter motor, and the internal combustion engine E is started from a point of time Ti and hence, the crankshaft rotational speed Nc arrives at an idling rotational speed Nid. The crankshaft rotational speed Nc is maintained to the idling rotational speed Nid and hence, the internal combustion engine E is warmed up.

In such a period, the rotation of the crankshaft is increased due to driving of the starter motor, and the internal combustion engine E is started from a point of time Ti and hence, the crankshaft rotational speed Nc arrives at an idling rotational speed Nid. The crankshaft rotational speed Nc is maintained to the idling rotational speed Nid and hence, the internal combustion engine E is warmed up.

In such a period, the rotation of the crankshaft is increased due to driving of the starter motor, and the internal combustion engine E is started from a point of time Ti and hence, the crankshaft rotational speed Nc arrives at an idling rotational speed Nid. The crankshaft rotational speed Nc is maintained to the idling rotational speed Nid and hence, the internal combustion engine E is warmed up.

In such a period, the rotation of the crankshaft is increased due to driving of the starter motor, and the internal combustion engine E is started from a point of time Ti and hence, the crankshaft rotational speed Nc arrives at an idling rotational speed Nid. The crankshaft rotational speed Nc is maintained to the idling rotational speed Nid and hence, the internal combustion engine E is warmed up.

In such a period, the rotation of the crankshaft is increased due to driving of the starter motor, and the internal combustion engine E is started from a point of time Ti and hence, the crankshaft rotational speed Nc arrives at an idling rotational speed Nid. The crankshaft rotational speed Nc is maintained to the idling rotational speed Nid and hence, the internal combustion engine E is warmed up.
gear, as indicated by a broken line in Fig. 5, a main shaft rotational speed $N_m$ of the main shaft 20 which is rotated together with the idling rotational speed $N_{id}$ of the main shaft 20 is also set to a value close to the idling rotational speed $N_{id}$, a rotational speed $N_1'$ (see a point of time $T_1'$ in Fig. 5).

[0088] When the inertia rotation attributed to the co-rotation of a large inertia mass of the inner sleeve 20i of the main shaft 20, the second clutch 27 and the first speed change driven idle gear n1 exhibits the relatively high rotational speed $N_1'$, the speed change gear is changed over from the neutral state to the first speed gear, and the inertia mass is instantaneously connected with another large inertia mass of parts ranging from the stopped fifth speed change driven gear n5 to the output-side counter shaft 51 and the like and hence, large impacts and noises are generated at the time of connection.

[0089] To the contrary, according to this embodiment, by performing the control in which the speed change gear mechanism 60 is automatically changed over from the neutral state to the first speed gear at the point of time $T_1$ where the engine rotational speed arrives at the predetermined low rotational speed $N_1$ considerably lower than the idling rotational speed $N_{id}$ after turning on the starter switch, it is possible to reduce the impact and noises attributed to the changeover from the neutral state to the first speed gear without providing any mechanism which suppresses the co-rotation of the main shaft 20 thus simplifying the structure, miniaturizing the internal combustion engine and reducing a manufacturing cost.

[0090] In the control method of the power transmission device according to this embodiment, the changeover from the neutral state to the first speed gear is automatically performed and hence, the impact and noises are small whereby there may be a case a rider is not aware of the starting ready state. Accordingly, a lamp may be turned on to inform the rider of the starting ready state.

[0091] Further, at the time of performing the changeover from the neutral state to the first speed gear, by performing a control which changes over the first speed gear to the neutral state and again performs the changeover from the neutral state to the first speed gear, the rider may be informed of the starting ready state by easily feeling operation sounds generated by the repetition of the changeover.

[0092] Further, the predetermined low rotational speed $N_1$ with which timing for changeover from the neutral state to the first speed gear is detected can be arbitrarily set and hence, by setting a rotational speed to an extent that more or less impact sounds are generated, the rider is informed of the starting ready state.

[0093] In the vehicle having the D-mode changeover switch 74 which allows a rider to intentionally bring the vehicle into the start ready state, when the D-mode changeover switch 74 is turned on, the lamp is turned on to inform the rider of the starting ready state.

[0094] Next, a control method of a power transmission device according to another embodiment is explained in conjunction with Fig. 6 and Fig. 7.

[0095] In a flowchart shown in Fig. 6, first of all, it is determined whether the ignition switch 73 is turned on or not (Step 11). If it is determined that the ignition switch 73 is turned on, processing advances to Step 12 in which it is determined whether the power transmission device is in a neutral state or not (Step 12). If it is determined that the power transmission device is not in the neutral state, processing leaves this routine, while if it is determined that the power transmission device is in the neutral state, processing advances to Step 13 in which counting of time is started. In Step 14, it is determined whether $t_1$ seconds elapse or not after starting the counting of time. If it is determined that $t_1$ seconds elapse, processing advances to Step 15 in which the speed change gear is changed over from the neutral state to the first speed gear.

[0096] That is, in the control method of the power transmission device, at a point of $T_1$ at which the predetermined time ($t_1$ seconds) elapses after turning on the ignition switch in the power transmission device 10, the speed change gear mechanism 50 is automatically changed over from the neutral state to the first speed gear.

[0097] This point of time $T_1$ is a point of time before a crankshaft rotational speed $N_c$ arrives at a steady-state idling rotational speed $N_{id}$, wherein in the example shown in Fig. 7, the point of time $T_1$ is before the point of time $T_s$ at which the starter switch is turned on.

[0098] Accordingly, in a stop state in which the crankshaft 2 is not also rotated, the fifth speed change driven shift gear n5 is connected to the first speed change driven idle gear n1 to change over the speed change gear from the neutral state to the first speed gear and hence, neither impacts nor noises are generated at the time of connection.

[0099] Even when the crankshaft 2 is rotated by turning on the starter switch and the crankshaft rotational speed $N_c$ is elevated, the inner sleeve 20i of the main shaft 20 is stopped by braking due to the connection of the fifth speed change driven shift gear n5 with the first speed change driven idle gear n1 and hence, the main shaft rotational speed $N_m$ remains at 0.

[0100] Also in the control method of the power transmission device of this embodiment, by alternately repeating lighting of the lamp and the changeover of the speed change mechanism between the neutral state and the first speed gear, the rider may be informed of the starting ready state.

[0101] Further, in the vehicle having the D-mode changeover switch 74, when the D-mode changeover switch 74 is turned on, the lamp is turned on to inform the rider of the starting ready state.

[0102] Here, in the example shown in Fig. 7, the point of time $T_1$ at which the predetermined time elapses after turning on the ignition switch comes before the point of time $T_s$ at which the starter switch is turned on. However, the point of time $T_1$ may come after the point of time $T_s$ at which the starter switch is turned on. In such a case,
the control method of the power transmission device becomes equal to the control method of the power transmission device of the embodiment shown in Fig. 5 and hence, impacts and noises which are generated at the time of changing over the speed change gear from the neutral state to the first speed gear can be suppressed to small values.

Further, a control method of a power transmission device according to another embodiment is explained in conjunction with Fig. 8 and Fig. 9.

In a flowchart shown in Fig. 8, first of all, it is determined whether the ignition switch 73 is turned on or not (Step 21). If it is determined that the ignition switch 73 is turned on, processing advances to Step 22 in which it is determined whether the power transmission device is in a neutral state or not (Step 22). If it is determined that the power transmission device is not in the neutral state, processing leaves this routine, while if it is determined that the power transmission device is in the neutral state, processing advances to Step 23, and the speed change gear is immediately changed over from the neutral state to the first speed gear.

That is, in the control method of the power transmission device, if it is determined that the power transmission device 10 is in the neutral state at a point of time at which the ignition switch is turned on, a speed change gear mechanism is automatically changed over from the neutral state to the first speed gear.

The crankshaft 2 is stopped at a point of time at which the ignition switch is turned on and hence, the fifth speed change driven shift gear n5 which is in a stopped state is connected to the first speed change driven idle gear n1 which is also in a stopped state thus changing over the speed change gear from the neutral state to the first speed gear and hence, impacts and noises are not generated at the time of the connection.

Also in the control method of the power transmission device of this embodiment, by alternately repeating lighting of the lamp and the changeover of the speed change mechanism between the neutral state and the first speed gear, the rider may be informed of the starting ready state.

Further, in the vehicle having the D-mode changeover switch 74, when the D-mode changeover switch 74 is turned on, the lamp is turned on to inform the rider of the starting ready state.

In the above-mentioned embodiments, the clutch mechanism of the power transmission device 10 adopts the hydraulic twin clutch 25. The invention is, however, applicable to a clutch mechanism constituted of one clutch.

Further, the twin clutch 25 of this embodiment is formed of a clutch which assumes an engaged state when oil pressure is applied. However, it is needless to say that the invention is also applicable to a clutch which assumes an engaged state when the oil pressure is released.

Still further, the clutch mechanism is applicable to a motor driven clutch as well as the hydraulic clutch.

A control method of a power transmission device for controlling a power transmission device which transmits a rotational power of a crankshaft (2) of an internal combustion engine (E) to an output side by way of a clutch mechanism (25) and a speed change mechanism (50), wherein the speed change mech-
anism (50) is automatically changed over from a neutral state to a first speed gear during a period from a point of time (Ti) at which an ignition switch is turned on to a point of time at which an engine rotational speed (Nc) arrives at a steady-state idling rotational speed (Nid) due to starting of an internal combustion engine (E).

characterized in that,
the speed change mechanism (50) is automatically changed over from the neutral state to the first speed gear at a point of time (T1) at which the engine rotational speed (Nc) arrives at a predetermined low-rotational speed (N1) lower than the idling rotational speed (Nid) by turning on a starter switch.

2. A control method of a power transmission device according to claim 1,
characterized in that,
the predetermined rotational speed (N1) is set to an extend that impact sounds are generated that can be noticed by the rider.

3. A control method of a power transmission device according any of the previous claims,
characterized in that,
a lamp (75) is turned on in the starting ready state.

4. A control method of a power transmission device according any of the previous claims,
characterized in that,
the control method performs after the changeover from neutral state to the first speed gear a change over the first speed gear to the neutral state and then again the changeover from the neutral state to the first speed gear and that the repetition of the changeover generates operation sounds.

5. A control method of a power transmission device according any of the previous claims,
characterized in that,
the speed change mechanism (50) is a constant-mesh speed change gear mechanism (50).

6. A control method of a power transmission device according any of the previous claims,
characterized in that,
the power transmission device comprises an electronic control unit (ECU) which controls the speed change mechanism (50) and the clutch mechanism (25).

7. A control method of a power transmission device according to claim 5,
characterized in that,
the electronic control unit (ECU) controls the clutch mechanism (25) via oil pressure control means (76).

8. A power transmission device which transmits a rotational power of a crankshaft (2) of an internal combustion engine (E) to an output side by way of a clutch mechanism (25) and a speed change mechanism (50), wherein the power transmission device is further adopted to automatically change over the speed change mechanism (50) from the neutral state to the first gear at a certain point of time (T1) so that the generation of impacts and noises due to the change over of the speed change mechanism is minimized,

characterized in that,
the speed change mechanism (50) is automatically changed over from the neutral state to the first speed gear at a point of time (T1) at which the engine rotational speed (Nc) arrives at a predetermined low-rotational speed (N1) lower than the idling rotational speed (Nid) by turning on a starter switch.

9. A power transmission device according to claim 8,
characterized in that,
the speed change mechanism (50) is a constant-mesh speed change gear mechanism (50).

10. A power transmission device according any of the claims 8-9,
characterized in that,
the power transmission device comprises an electronic control unit (ECU) which controls the speed change mechanism (50) and the clutch mechanism (25).

11. A power transmission device according to the claim 10,
characterized in that,
the electronic control unit (ECU) controls the clutch mechanism (25) via oil pressure control means (76).

Patentansprüche

1. Ein Steuerungsverfahren einer Kraftübertragungsvorrichtung zur Kontrolle einer Kraftübertragungsvorrichtung, welche die rotierende Kraft einer Kurbelwelle (2) eines Verbrennungsmotors (E) auf eine Abtriebsseite mittels eines Kupplungsmechanismus (25) und eines Mechanismus zum Wechseln der Geschwindigkeit (50) überträgt, wobei der Mechanismus zum Wechseln der Geschwindigkeit (50) automatisch von einer neutralen Stellung in den ersten Gang schaltet, in einer Zeitspanne von einem Zeitpunkt (Ti), bei welchem der Zündungsschalter eingeschaltet wird, zu einem Zeitpunkt, an welchem eine Motordrehzahl (Nc) infolge des Starts eines Verbrennungsmotors (E) eine stationäre Leerlaufmotor-drehzahl (Nid) erreicht hat, dadurch gekennzeichnet, dass,
der Mechanismus zum Wechseln der Geschwindigkeit (50) automatisch von einer neutralen Stellung in den ersten Gang geschaltet wird, zu einem Zeitpunkt...
(T1), bei welchem die Motordrehzahl \((N_c)\) eine vorher festgelegte Niedrigdrehzahl \((N_1)\) erreicht, welche geringer ist als die Leerlaufmotordrehzahl \((N_{id})\), durch das Drücken des Starterknopfs.

2. Ein Steuerungsverfahren einer Kraftübertragungs- vorrichtung nach Anspruch 1, **durchgekennzeichnet, dass**, die vorher festgelegte Drehzahl \((N_1)\) derart festgelegt ist, dass Eingriffsgeräusche erzeugt werden, die durch den Fahrer bemerkt werden können.


5. Ein Steuerungsverfahren einer Kraftübertragungs- vorrichtung nach allen vorangehenden Ansprüchen, **durchgekennzeichnet, dass**, der Mechanismus zum Wechsel der Geschwindigkeit \((50)\) ein im ständigen Eingriff befindliches Zahnradwechselgetriebe \((50)\) ist.


7. Ein Steuerungsverfahren einer Kraftübertragungs- vorrichtung nach Anspruch 6, **durchgekennzeichnet, dass**, die elektronische Kontrolleinheit \((ECU)\) den Kupplungsmechanismus \((25)\) mittels Öldrucksteuermitteln steuert \((76)\).

8. Eine Kraftübertragungsvorrichtung, welche die rotierende Kraft einer Kurbelwelle \((2)\) eines Verbrennungsmotors \((E)\) auf eine Abtriebsseite mittels eines Kupplungsmechanismus \((25)\) und eines Mechanismus zum Wechseln der Geschwindigkeit \((50)\) überträgt, wobei die Kraftübertragungsvorrichtung ferner derart ausgelegt ist, dass sie den Mechanismus zum Wechseln der Geschwindigkeit \((50)\) automatisch von einer neutralen Stellung in den ersten Gang wechselt, bei einem bestimmten Zeitpunkt \((T_1)\), so dass die Entstehung von Erschütterungen und Geräuschen infolge des Wechsels durch den Mechanismus zum Wechseln der Geschwindigkeit \((50)\) minimiert wird, **durchgekennzeichnet, dass**, der Mechanismus zum Wechsel der Geschwindigkeit \((50)\) automatisch von einer neutralen Stellung in den ersten Gang zu dem Zeitpunkt \((T_1)\) wechselt, bei welchem die Motordrehzahl \((N_c)\) eine vorher festgelegte Niedrigdrehzahl \((N_1)\) erreicht, welche geringer ist als die Leerlaufmotordrehzahl \((N_{id})\), durch das Drücken des Starterknopfs.

9. Eine Kraftübertragungsvorrichtung nach Anspruch 8, **durchgekennzeichnet, dass**, der Mechanismus zum Wechsel der Geschwindigkeit \((50)\) ein im ständigen Eingriff befindliches Zahnradwechselgetriebe \((50)\) ist.

10. Eine Kraftübertragungsvorrichtung nach jedem der Ansprüche 8-9, **durchgekennzeichnet, dass**, das Kraftübertragungsvorrichtung eine elektronische Kontrolleinheit \((ECU)\) aufweist, welche den Mechanismus zum Wechsel der Geschwindigkeit \((50)\) sowie den Kupplungsmechanismus \((25)\) steuert.

11. Eine Kraftübertragungsvorrichtung nach Anspruch 10, **durchgekennzeichnet, dass**, die elektronische Kontrolleinheit \((ECU)\) den Kupplungsmechanismus \((25)\) mittels Öldrucksteuermitteln steuert \((76)\).

**Revendications**

1. Procédé de commande d'un dispositif de transmission de puissance permettant de commander un dispositif de transmission de puissance qui transmet une puissance de rotation d'un vilebrequin \((2)\) d'un moteur à combustion interne \((E)\) à un côté sortie à l'aide d'un mécanisme d'embrayage \((25)\) et d'un mécanisme de changement de vitesse \((50)\), dans lequel le mécanisme de changement de vitesse \((50)\) est automatiquement permuté d'un état de point mort à un premier pignon de vitesse pendant une période allant d'un instant \((T_i)\) auquel un interrupteur d'allumage est allumé jusqu'à un instant auquel une vitesse de rotation de moteur à combustion interne \((N_c)\) arrive à une vitesse de rotation au ralenti en régime permanent \((N_{id})\) en raison d'un démarrage d'un moteur à combustion interne \((E)\), **caractérisé en ce que**, le mécanisme de changement de vitesse \((50)\) est
automatiquement permuté de l’état de point mort au premier pignon de vitesse à un instant (T1) auquel la vitesse de rotation de moteur (Nc) arrive à une faible vitesse de rotation prédéterminée (N1) inférieure à la vitesse de rotation au ralenti (Nid) en allumant un interrupteur de démarrage.

2. Procédé de commande d’un dispositif de transmission de puissance selon la revendication 1, caractérisé en ce que, la vitesse de rotation prédéterminée (N1) est fixée dans une mesure telle que des bruits d’impact sont générés, lesquels peuvent être relevés par le motocycliste.

3. Procédé de commande d’un dispositif de transmission de puissance selon l’une quelconque des revendications précédentes, caractérisé en ce que, une lampe (75) est allumée dans l’état prêt à démarrer.

4. Procédé de commande d’un dispositif de transmission de puissance selon l’une quelconque des revendications précédentes, caractérisé en ce que, le procédé de commande réalise après la permutation de l’état de point mort au premier pignon de vitesse, une permutation du premier pignon de vitesse à l’état de point mort puis à nouveau la permutation de l’état de point mort au premier pignon de vitesse et en ce que la répétition de la permutation génère des bruits de fonctionnement.

5. Procédé de commande d’un dispositif de transmission de puissance selon l’une quelconque des revendications précédentes, caractérisé en ce que, le mécanisme de changement de vitesse (50) est un mécanisme de pignon de changement de vitesse à prise constante (50).

6. Procédé de commande d’un dispositif de transmission de puissance selon l’une quelconque des revendications précédentes, caractérisé en ce que, le dispositif de transmission de puissance comprend une unité de commande électronique (UCE) qui commande le mécanisme de changement de vitesse (50) et le mécanisme d’embrayage (25).

7. Procédé de commande d’un dispositif de transmission de puissance selon la revendication 5, caractérisé en ce que, l’unité de commande électronique (UCE) commande le mécanisme d’embrayage (25) via un moyen de commande de pression d’huile (76).

8. Dispositif de transmission de puissance qui transmet une puissance de rotation d’un vilebrequin (2) d’un moteur à combustion interne (E) à un côté sortie à l’aide d’un mécanisme d’embrayage (25) et d’un mécanisme de changement de vitesse (50), dans lequel le dispositif de transmission de puissance est en outre adapté pour permettre automatiquement le mécanisme de changement de vitesse (50) de l’état de point mort au premier pignon à un certain instant (T1) de sorte que la génération d’impacts et de bruits dus à la permutation du mécanisme de changement de vitesse est minimisée, caractérisé en ce que, le mécanisme de changement de vitesse (50) est automatiquement permuté de l’état de point mort au premier pignon de vitesse à un instant (T1) auquel la vitesse de rotation de moteur à combustion interne (Nc) arrive à une faible vitesse de rotation prédéterminée (N1) inférieure à la vitesse de rotation au ralenti (Nid) en allumant un interrupteur de démarrage.

9. Dispositif de transmission de puissance selon la revendication 8, caractérisé en ce que, le mécanisme de changement de vitesse (50) est un mécanisme de pignon de changement de vitesse à prise constante (50).

10. Dispositif de transmission de puissance selon l’une quelconque des revendications 8 à 9, caractérisé en ce que, le dispositif de transmission de puissance comprend une unité de commande électronique (UCE) qui commande le mécanisme de changement de vitesse (50) et le mécanisme d’embrayage (25).

11. Dispositif de transmission de puissance selon la revendication 10, caractérisé en ce que, l’unité de commande électronique (UCE) commande le mécanisme d’embrayage (25) via un moyen de commande de pression d’huile (76).
[Fig. 3]

ECU

clutch oil pressure control means

speed change motor

speed change sensor

engine rotational speed sensor

[Diagram of a control system with various components labeled]

15
[Fig. 6]

1. start
2. S11: ignition on?
   - Y: neutral?
   - N: S13
3. S13: start counting of time
   - Y: S14
   - N: S15
4. S14: 11 seconds elapsed after starting counting of time?
   - Y: changed over to first speed gear
   - N: S15
5. S15: end

[Fig. 7]

- Nid: crankshaft rotational speed Nc
- n: rotational speed
- T0, T1, T2: time
- Nm: main shaft rotational speed

The diagram illustrates the logic flow of a process with decision points and actions based on conditions.
[Fig. 8]

start

S21 ignition on? N

Y

S22 neutral? N

Y

S23 changed over to first speed gear

end

[Fig. 9]

rotational speed n

Nid

crankshaft rotational speed Nc

main shaft rotational speed Nm

Ti

T1

Ts

time t
REFERENCES CITED IN THE DESCRIPTION

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