System for controlling an electromagnetic clutch for a vehicle.

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Description

The present invention relates to a system for controlling an electromagnetic clutch for an automatic transmission.

An automobile provided with a continuously variable belt-drive transmission with an electromagnetic clutch is disclosed in EP-A-151 038 which discloses the features in the pre-characterising part of claim 1 of this application. The electromagnetic clutch of the transmission is controlled by a control system to provide various operational modes such as a starting mode, reverse excitation mode, drag mode, and two modes of lock-up engagement which correspond to an accelerator pedal releasing condition and an accelerator depression condition. One of the modes is selected in accordance with a position of a selector lever and driving conditions to control the electromagnetic clutch.

In this system, as shown in Figure 8, the engine speed (H) rises above a predetermined engine speed (M), which corresponds to a minimum changing line M of a transmission ratio, in a low vehicle speed range when the choke valve is closed. In such a condition, the vehicle accelerates because of the high engine speed regardless of the intention of the driver. In order to prevent the acceleration of the vehicle, the driver therefore depresses the brake pedal to brake the vehicle. However, since the electromagnetic clutch is locked at a vehicle speed higher than a predetermined speed Vc (Figure 8), a large force must be applied to the brake pedal.

The object of the present invention is to provide a system which operates to partially disengage the electromagnetic clutch so as to allow it to slip, if it should lock up under the "chocked" condition of the engine, whereby the vehicle can be braked by a small braking force, moreover preventing overheating of the clutch by keeping slip to a minimum.

According to present invention as defined in claim 1, there is provided a system for controlling an electromagnetic clutch for a motor vehicle having a continuously variable transmission which has a drive range, reverse range and neutral range, and selector lever for selecting the ranges, the system comprising:

vehicle speed detecting means for producing a first vehicle speed signal at a first predetermined low speed;
first switch means for detecting the position of the selector lever and for producing a drive signal when the selector lever is at drive range position;
second switch means for producing a release signal in response to the release of the accelerator pedal of the vehicle;
third switch means for producing a choke signal dependent on the closing of the choke valve;
first control means responsive to the first vehicle speed signal and to the drive signal for producing a lock-up current signal;
output decision means responsive to the lock-up current signal for controlling the current passing through the clutch coil to lock-up the clutch, characterised in that said vehicle speed detecting means are further provided for producing a second vehicle speed signal when vehicle speed is between the first predetermined low speed and a second predetermined speed higher than the first low speed;
second control means are provided to respond to the second vehicle speed signal and to the release signal for producing a current reducing signal when the choke signal is present;
said output decision means are further responsive to the current reducing signal so as to reduce the current to slip the clutch.

One embodiment of the invention will now be described by way of example with reference to the accompanying drawings in which:

Figures 1a and 1b are sectional views of a continuously variable belt-drive transmission to which the present invention is applied;
Figure 2 is a schematic diagram showing a control system as used in connection with the present invention;
Figure 3a and 3b show a block diagram of a control unit according to the present invention;
Figure 4 is a flow chart showing the operation of the control system;
Figure 5 is a graph showing regions of various modes;
Figure 6 and 7 are graphs showing variation of clutch current;
Figure 8 is a graph showing relationships between engine speed and vehicle speed in the prior art and the present invention;
Figure 9 is a graph showing relationship between vehicle speed and clutch current; and
Fig. 10 is a flowchart showing the operation of the system according to the present invention.

Referring to Figs. 1a and 1b, a continuously variable belt-drive automatic transmission for a vehicle, to which the present invention is applied, comprises an electromagnetic powder clutch 1, a continuously variable belt-drive transmission 2, a selector device 3, pulleys and belt device 4, final reduction device 5, and a pressure oil control circuit (not shown). The electromagnetic powder clutch 1 is provided in a housing 6. The selector device 3, pulleys and belt device 4, and final reduction device 5 are provided in a main housing 7 and a side housing 8. A crankshaft 10 of an engine E is connected to an annular drive member 12 through a drive plate 11 of the electromagnetic powder clutch 1. The electromagnetic powder clutch comprises a driven member 14, a magnetizing coil 15 provided in the driven member 14. The driven member 14 has its outer periphery spaced from the inner periphery of the drive member 12 by a gap 16, and a powder chamber 17 is defined between the drive member 12 and driven member 14. Powder of magnetic material is provided in the powder chamber 17. The driven member 14 is secured to an input shaft 13 of the belt-drive transmission. A holder secured to the driven member 14 carries slip rings 18 which are electrically connected to the coil 15. The coil 15 is supplied through brushes 19 and slip rings 18 with current from a control circuit for the electromagnetic powder clutch.

When the magnetizing coil 15 is excited by the clutch current, driven member 14 is magnetized to produce a magnetic flux passing through the drive
member 12. The magnetic powder is aggregated in the gap 16 by the magnetic flux and the driven member 14 is engaged with the drive member 12 by the powder. On the other hand, when the clutch current is cut off, the drive and driven members 13 and 14 are disengaged from one another.

In the belt-drive transmission 2, the selector device 3 is provided between the input shaft 13 and a main shaft 20. The main shaft 20 is cylindrical and is disposed coaxially with the input shaft 13. The selector device 3 comprises a drive gear 21 integral with input shaft 13, reverse driven gear 22 rotatably mounted on the main shaft 20, and a synchronizer 27 mounted on the main shaft 20. The drive gear 21 meshes with one of counter gears 24 rotatably mounted on a shaft 23. Another gear of the counter gears 24 engages with an idler gear 26 rotatably mounted on a shaft 25, which in turn engages with the driven gear 22.

The synchronizer 27 comprises a hub 28 secured to the main shaft 20, a synchronizer sleeve 29 slidably engaged with the tube 28 with splines, and synchronizer rings 30 and 31. The synchronizer sleeve 29 is adapted to engage with splines of the drive gear 21 or with splines of driven gear 22 through rings 30 or 31.

At a neutral position (N-range) or a parking position (P-range) of a selector lever 50 (Fig. 2), the sleeve 29 does not engage either gear, so that the main shaft 20 is disconnected from the input shaft 13. When the sleeve 29 is engaged with the gear 21, the input shaft 13 is connected to the main shaft 20 through the gear 21 and synchronizer 27 to provide a drive range (D-range) or a high engine speed drive range (Ds-range).

When the sleeve 29 is engaged with the gear 22, the input shaft 13 is connected to the main shaft 20 through gears 21, 24, 26 and 22 to provide a reverse driving position (R-range).

The main shaft 20 has an axial passage in which an oil pump driving shaft 42 directly connected to crankshaft 10 is mounted. An output shaft 35 is provided in parallel with the main shaft 20. A drive pulley 36 and a driven pulley 37 are mounted on shafts 20 and 35. A fixed conical disc 36a of the drive pulley 36 is integral with main shaft 20 and an axially movable conical disc 36b is axially slidably mounted on the main shaft 20. The movable conical disc 36b also slides in a cylinder secured to the main shaft 20 to form a servo device 38. A chamber 36b of the servo device 38 communicates with an oil pump 41 through the pressure oil control circuit. The oil pump 41 is driven by the shaft 42.

A fixed conical disc 37a of the driven pulley 37 is formed on the output shaft 35 opposite the movable disc 36b and a movable conical disc 37b is slidably mounted on the shaft 35 opposite disc 36a. The movable conical disc 37b has a cylindrical portion in which a piston portion of the output shaft 35 is slidably engaged to form a servo device 39. A chamber 39b of the servo device 39 is communicated with the oil pump 41 through the pressure oil control circuit. A spring 40 is provided to urge the movable conical disc 37b to the fixed conical disc 37a. A drive belt 34 engages with the drive pulley 36 and the driven pulley 37.

Secured to the output shaft 35 is a drive gear 43 which engages with an intermediate reduction gear 44a on an intermediate shaft 44. An intermediate gear 45 on the shaft 44 engages with a final gear 46. Rotation of the final gear 46 is transmitted to axles 48 and 49 of the vehicle driving wheels through a differential 47.

The pressure oil control circuit is responsive to vehicle speed, engine speed and throttle valve position for controlling the oil from the oil pump 41 to servo devices 38 and 39 thereby to move discs 36b and 37b. Thus, transmission ratio is continuously changed. When the Ds-range is selected, the transmission ratio is increased by the operation of the pressure oil control circuit.

Referring to Fig. 2 showing a control system, an R-range switch 51, D-range switch 52, Ds-range switch 53 are provided to produce high level output signals at respective positions of the selector lever 50. An accelerator pedal switch 55 is provided to produce an output signal when an accelerator pedal 54 of the vehicle is depressed, and an accelerator pedal position switch 56 is provided to produce an output signal when the accelerator pedal is depressed over a predetermined degree. The accelerator pedal switch 55 and accelerator pedal positions switch 56 may be substituted with a throttle valve switch and throttle position switch, respectively. A choke switch 57 produces an output signal when a choke valve of the engine is closed, and an air conditioner switch 58 produces an output signal at the operation of an air conditioner. An ignition pulse generator 60 produces pulses dependent on ignition signal from an ignition coil 59, representing engine speed. A vehicle speed signal generator 62 produces pulses dependent on an output from a speedometer 61. These output signals and pulses are applied to a control unit 63 which controls the clutch current in dependence on the input signals.

Referring to Figs. 3a and 3b, the control unit 63 is provided with an engine speed deciding section 64 applied with the ignition pulses from the generator 60, and a vehicle speed deciding section 65 applied with the pulses from the generator 62. A reverse excitation mode deciding section 66 decides that output sinals from R-range switch 51, D-range switch 52 and Ds-range switch 53 are at low levels, and the transmission is at P-range or N-range, and produces a reverse excitational signal. The reverse excitation signal is applied to an output deciding section 67, so that a small reverse current flows in the coil 15 to excite the coil in reverse. When engine speed is below 300 rpm, an engine speed deciding section 64 produces a low engine speed signal which is applied to the reverse excitation mode deciding section 66 to excite the coil 15 in reverse. The output signals of the accelerator pedal depression switch 55 and vehicle speed deciding section 65, and the drive range select signals from the reverse excitation mode deciding section 66 are applied to a clutch current mode deciding section 68 outputs of which are applied to a start mode providing section 69, drag mode providing section 70, clutch lock-up mode (A) provide
section 71 at releasing the accelerator pedal, and clutch lock-up mode (B) provide section 72 at depressing the accelerator pedal.

The start mode provide section 69 decides clutch current dependent on the engine speed represented by the output from the engine speed deciding section 64. When the choke switch 57 or air conditioner switch 58 is turned on, clutch current having a high stall speed is decided. When the accelerator pedal is released, the drive mode provide section 70 decides a small current dependent on an output representing low vehicle speed from the vehicle speed deciding section 65 and on the output of clutch current mode deciding section 68 at the release of the accelerator pedal. When the vehicle speed decreases below a predetermined low speed, the clutch current becomes zero to disengage the clutch. The clutch lock-up mode (A) provide section 71 decides a small lock-up current in response to the output of the accelerator pedal switch 55 at the release thereof at middle and high vehicle speed. Further, when choke switch 57 is ON, the characteristic of the clutch current is decided dependent on output signals of the accelerator pedal position switch 56, engine speed deciding section 64 and vehicle speed deciding section 65. While the vehicle speed is below a predetermined speed $V_N$ (Fig. 8), which is higher than the lock-up speed $V_L$, and the engine speed is above a predetermined speed, the clutch current is decreased so as to increase slipping of the clutch. The clutch current is increased to reduce the slipping of the clutch when the engine speed decreases below the predetermined speed. When D-Range switch 53 is ON, the clutch current is cut off at a lower vehicle speed than the D-range. The clutch lock-up mode (B) provide section 72 decides a large lock-up current in response to the output of the accelerator pedal switch at the depression at middle and high vehicle speed. Clutch current at D-Range is the same as the mode (A). Outputs of sections 69 to 72 are applied to the output deciding section 67 to control the clutch current.

Describing the operation of the control system with reference to Figs. 4 and 6, at a deciding step B0 (Fig. 4), it is determined whether the vehicle is at the reverse excitation mode. If the reverse excitation mode is detected, reverse clutch current flows in the coil 15. When engine speed is at a very low speed, for example below 300 rpm, the reverse clutch current flows at all ranges (Fig. 5). At a deciding step B1, clutch current supply mode is determined. If the accelerator pedal is released at a low vehicle speed, the clutch current is cut off at a small drag current flows. If the accelerator pedal is depressed, clutch current for starting the vehicle flows. At middle or high vehicle speed, when the accelerator pedal is released, a small lock-up current (mode A) flows, and at the depression of the pedal, a large lock-up current (mode B) flows.

When the choke switch 57 is ON, the clutch current is controlled in accordance with the flowchart in Fig. 10. At a step S1, it is determined whether the accelerator pedal is released. If the accelerator pedal is released, the vehicle speed is detected at a step S2. If the vehicle speed is lower than the predetermined low speed $V_H$ (Fig. 8) the clutch current I is decreased at a step S3 by subtracting $\Delta I$ from the amount of the basic current $I_c$ (which is in the present case, a lock-up current). Thus, slipping of the clutch increases. At a step S4, it is decided whether the engine speed $Ne$ is higher than a predetermined speed $Neu$ or not. When $Ne$ is higher than $Neu$, the program is returned to step S3 for further reducing the clutch current, thereby increasing the slipping of the clutch. If the engine speed $Ne$ is lower than $Neu$, the clutch current $I$ is increased by adding $\Delta I$ to $I_c$ ($I_c + \Delta I$) at a step S5. At a step S6, it is further decided whether the vehicle speed is higher or lower than the predetermined lock-up speed $V_L$ of Figure 8. If the vehicle speed $V$ is higher than the predetermined speed $V_L$, the program is returned to step S4.

If it is lower ($V < V_L$), the program ends. Thus, the vehicle speed is controlled to a proper speed without braking the vehicle, avoiding the elevating of the temperature of the clutch.

Referring to Figures 6 and 7, at the N-range or P-range, a reverse current $i$ flows in the coil. At the D-range, if the accelerator pedal is not depressed, a small drag current $b$ flows to produce a small drag torque, thereby reducing the amount of plays between gears and decreasing the static friction torque in the belt and pulley device. When the accelerator pedal is depressed, a clutch current $c_1$ flow in proportion to engine speed. Clutch current $c_2$ flows under the operation of the air conditioner, and clutch current $c_3$ is for the operation when the choke valve is closed. When the vehicle speed reaches a predetermined speed ($V_3$ or $V_4$ in Figure 5), a large lock-up current $d$ for entirely engaging the clutch flows to lock up the clutch. When the accelerator pedal is released to decelerate the vehicle, a small lock-up current $e$ flows, so that electric power consumption is reduced. When the vehicle speed decreases below a predetermined value ($V_4$ in Fig. 5), the clutch current becomes zero $f$. When the vehicle speed further decreases below a predetermined value ($V_3$ or $V_4$), the small drag current $b$ flows. When the vehicle is decelerated at the D-range or R-range, the small drag current $b$ flows at a lower vehicle speed than the D-range as shown by reference $e$ in Fig. 7. Thus, sufficient engine braking effect is provided in a lower vehicle speed range.

From the foregoing, it will be understood that in the system of the present invention when the choke valve is closed, the clutch is released from the lock-up mode and allowed to slip, so that acceleration of the vehicle is controlled. Accordingly, since braking of the vehicle is not necessary, overheating of the clutch can be prevented.

**Claims**

1. A system for controlling an electromagnetic clutch (1) for a motor vehicle having a continuously variable transmission (4) which has a drive range (D), reverse range (R) and neutral range (N), and a selector lever (50) for selecting the ranges, the system comprising:

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vehicle speed detecting means (62) for producing a first vehicle speed signal at a first predetermined low vehicle speed (VL);

first switch means (51-53) for detecting the position of the selector lever and for producing a drive signal when the selector lever is at drive range position (D, Ds, R);

second switch means (56) for producing a release signal in response to the release of the accelerator pedal (S4) of the vehicle;

third switch means for producing a choke signal dependent on the closing of a choke valve;

first control means (71) responsive to the first vehicle speed (VL) signal and to the drive signal for producing a lock-up current signal;

output decision means (67) responsive to the lock-up current signal for controlling the current passing through the clutch coil to lock-up the clutch, characterised in that said vehicle speed detecting means (62) are further provided for producing a second vehicle speed signal when vehicle speed is between the first predetermined low vehicle speed and a second predetermined vehicle speed (VH) higher than the first low vehicle speed (VL);

second control means are provided to respond to the second vehicle speed (VH) signal and to the release signal for producing a current reducing signal (at S2, S3) when the choke signal is present;

said output decision means (67) are further responsive to the current reducing signal so as to reduce the current to slip the clutch.

2. A system according to claim 1 further comprising third control means (at S4) for controlling the slippage of the clutch so as to keep the engine speed (Neu) constant.

Reivendications

1. Système pour contrôler un embrayage électromagnétique (1) pour un véhicule à moteur ayant une transmission variable en continu (4) avec une position (D) de conduite, une position de marche arrière (R) et une position neutre (N), et un levier de sélection (40) pour choisir les positions, le système comprenant des moyens (62) pour détecter la vitesse du véhicule, pour produire un premier signal de vitesse du véhicule, à une première prédéterminée vitesse lente du véhicule (VL), des premiers moyens de commutation (51, S3) pour détecter la position du levier de sélection et pour produire un signal de conduite lorsque le levier de sélection est dans la position de conduite (D, Ds, R), des seconds moyens de commutation (56) pour produire un signal de relâchement en réponse à un relâchement de la pédale d'accélérateur (S4) du véhicule, des troisièmes moyens de commutation pour produire un signal d'embrayage dépendant de la fermeture d'une valve d'embrayage, des premiers moyens de contrôle (71) qui en réponse au premier signal (VL) de vitesse du véhicule et au signal de conduite commandent un signal de fermeture du courant, des moyens (67) de détection de puissance qui en réponse au signal de fermeture du courant contrôlent le courant passant à travers l'enroulement de l'embrayage pour bloquer l'embrayage, caractérisé en ce que les moyens (62) pour détecter la vitesse du véhicule sont, de plus agencés pour produire un second signal de la vitesse du véhicule lors-que la vitesse du véhicule est située entre la première prédéterminée vitesse lente et une seconde vitesse prédéterminée du véhicule (VH) supérieure à la première prédéterminée vitesse lente (VL), des seconds moyens de contrôle étant prévus pour répondre au second signal (VH) de la vitesse du véhicule et au signal de relâchement pour produire un signal de réduction de courant (S2, S3) lorsque le
signal d'embrayage est présent, lesdits moyens de
décision de puissance (67) étant de plus, sensibles
au signal de réduction de courant afin de réduire le
courant de calage de l'embrayage.
2. Système pour contrôler unembrayage électro-
magnétique pour un véhicule à moteur, selon la
revendication 1, caractérisé en ce qu'il comprend, de
plus, des troisièmes moyens (S4) pour contrôler le
calage de l'embrayage afin de permettre une vitesse
constante du moteur (Neu).
FIG. 3a
## FIG. 5

<table>
<thead>
<tr>
<th>ACCELERATOR PEDAL</th>
<th>RELEASE</th>
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<td>V1OFF</td>
<td>V2OFF</td>
<td>V3OFF</td>
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### SELECTOR LEVER POSITION

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<th>ENGINE SPEED</th>
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<th>BELOW 300 rPm</th>
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<tr>
<td>P</td>
<td>REVERSE EXCITATION</td>
<td>REVERSE EXCITATION</td>
</tr>
<tr>
<td>N</td>
<td>DRAG CURRENT</td>
<td>CURRENT ZERO</td>
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<tr>
<td>D</td>
<td>LOCK-UP CURRENT</td>
<td>STARTING CURRENT</td>
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<td>Ds</td>
<td>REVERSE EXCITATION</td>
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</tr>
<tr>
<td>R</td>
<td>REVERSE EXCITATION</td>
<td>REVERSE EXCITATION</td>
</tr>
</tbody>
</table>
FIG. 6

CLUTCH CURRENT

TIME

P(N)-RANGE

D-RANGE

DEPRESSION OF ACCELERATOR PEDAL

RELEASE OF ACCELERATOR PEDAL

c1
c2
c3

d
FIG. 8

FIG. 9
FIG. 10