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(54) **Method for generating a pedal output signal of an accelerator pedal**

Vorrichtung zur Erzeugung eines Fahrpedalsignals

Méthode pour générer un signal de sortie d'une pédale d'accélérateur

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Description

Field of the invention

[0001] The present invention generally relates to a method for generating a pedal output signal of an accelerator pedal.

Background of the invention

[0002] In order to meet the demands of today's high-tech vehicles, internal combustion engines have been equipped with an electronic throttle control (ETC). On ETC applications, displacements of the accelerator pedal are electronically determined and transmitted. For example, a sensor is coupled to the accelerator pedal and the position of the pedal is converted into a pedal output signal supplied to the ETC. As the pedal output signal depends on the pedal position, it is used as an indication of the pedal position by the ETC.

[0003] Such Engines equipped with ETC are for example known from DE 44 03 604 A1, EP 0 962 350 A2 and US 4,881,428. They describe specific control strategies of the throttle valve position based on electronically determined pedal position information.

[0004] If a precise control of the intake air flow can be achieved with such ETC, it has however been observed that drivers have trouble to get accustomed to the feel of an accelerator pedal that is no longer linked with a cable and a return spring to the throttle blade. As a consequence, they often do not entirely release the accelerator pedal before depressing the clutch pedal, thereby causing engine speed flares during gearshifts.

[0005] JP 63 134829 describes a throttle valve control device, that aims at removing the fluctuation component of an accelerator operation quantity. This is done by adding hysteresis characteristics to the accelerator operation quantity to be detected by an acceleration quantity detecting means, and transmitting the accelerator operation quantity with the hysteresis characteristics to the ETC.

Object of the invention

[0006] The object of the present invention is to provide a method for generating a pedal output signal for ETC, which permits to reduce engine speed flares and more generally to improve a vehicle's driveability. This object is achieved by a method as claimed in claim 1.

Summary of *the invention*

[0007] A method in accordance with the invention generally concerns the generation of a pedal output signal of an accelerator pedal for electronic load control of an internal combustion engine. The pedal output signal depends on the position of the accelerator pedal. Therefore, a variation of the pedal output signal may be produced by a displacement of said accelerator pedal. It shall be appreciated that, under given conditions, a given absolute variation in said pedal output signal is generated by a different accelerator pedal displacement depending on whether the accelerator pedal is depressed or released. This means that, under given conditions, a different pedal output signal is generated for a same pedal position depending on whether the accelerator pedal has been depressed or released.

[0008] It follows that the pedal output signal is no longer generated so as to simulate a conventional accelerator pedal, i.e. mechanical accelerator pedal, producing a unique response of the engine to a given pedal displacement respectively a given pedal position, irrespective of acceleration or deceleration. On the contrary, the method of the invention permits to generate, in definable conditions, a different pedal output signal for a same pedal position. Therefore, the response of the engine to a pedal displacement can be adapted in function of preferred driving behaviors, thereby improving the driveability of the vehicle.

[0009] Advantageously, a given absolute variation in said pedal output signal is produced by a shorter accelerator pedal displacement when said accelerator pedal is released than when it is depressed. This means that a pedal output signal indicating an entirely released pedal, i.e. an idle output signal, may be generated before the accelerator pedal has been entirely released. A first advantage of this method is that the engine speed will earlier reach the idle engine speed, thereby reducing engine speed flares during gearshifts. Secondly, even if a driver doesn't entirely release the pedal during a gearshift, an idle output signal can be generated to prevent engine speed flares.

[0010] However, it will be understood that, anticipating the pedal position for which an idle output signal is generated introduces an offset in the accelerator pedal, which under certain conditions may prove troublesome. Indeed, after a series of accelerations and decelerations the driver may arrive at a point where the pedal is almost entirely depressed and where an idle output signal is generated, thereby hindering acceleration. In order to prevent such a situation, given conditions for generating a different pedal output signal for a same pedal position will be preferably defined.

[0011] An initial pedal movement is to depress the accelerator pedal from the entirely released pedal position. When the accelerator pedal is depressed from this entirely released pedal position, the pedal output signal may be generated according to an acceleration function with the actual pedal position as an argument. Now, if the pedal output signal is generated according to the acceleration function, i.e. the pedal is being depressed, and if the accelerator pedal is suddenly released, then the pedal output signal is generated according to a deceleration function. The deceleration function is steeper than the acceleration function, thereby ensuring a rapid decrease of the pedal output signal to the idle output signal.

[0012] As previously explained, generating the pedal output signal according to the deceleration function implies an offset in the accelerator pedal. Thus, the deceleration function already generates an idle output signal for an offset pedal position different from the entirely released pedal position. Once the accelerator pedal has been released to the offset pedal position, it is clear that if the accelerator pedal is further released the pedal output signal has to remain an idle output signal. Therefore, if the accelerator pedal is further released from the offset pedal position, then the deceleration function is preferably translated so as to generate an idle signal output for the actual pedal position.

[0013] In some cases, the deceleration function, or a translation thereof, may be used to generate the pedal output signal when the pedal has been released and is subsequently depressed. Indeed, using the acceleration function each time that the pedal is depressed and using the deceleration function each time that the accelerator pedal is released would produce discontinuities in the pedal output signal. In case that the pedal has been released and is subsequently depressed, the pedal output signal is therefore preferably generated according to the deceleration function or to a translation thereof, i.e. an analogous function which is parallel shifted, until it reaches the pedal output signal that would be generated according to the acceleration function. Then the pedal output signal will be generated according to the acceleration function.

[0014] The deceleration function is translated so as to obtain a coherent and continuous pedal output signal. If the accelerator pedal has been released from the offset pedal position to a given pedal position and if it is depressed again, then the pedal output signal is generated according to the deceleration function shifted or translated by a value corresponding to the difference between the offset pedal position and the given pedal position. Hence, this shifted deceleration function generates an idle output signal for said given pedal position and the pedal output signal varies as with the deceleration function when the accelerator pedal is depressed.

[0015] In a preferred embodiment, the acceleration function is of the form:

$$f_{acc}(\text{pedal position}) = A1*\text{pedal position},$$

with f_{acc}(entirely released pedal position)=idle output signal ; and the deceleration function is of the form:

$$f_{dec}(\text{pedal position}) = A2*(\text{pedal position - pedal offset}),$$

with A2>A1 and f_{dec}(offset pedal position)=idle output signal.

It has to be noted, that the method described above can be used as well for the control of a gasoline (petrol) engine (e.g. by electronic throttle control) as for the control of a diesel engine.

Brief description of the drawings

[0016] The present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Fig.1:	is a graph of the functions used in a preferred embodiment of the method of the invention;
Fig.2:	is a flowchart of the present method;
Fig.3 and Fig.4:	illustrate the variations in pedal position and pedal output signal during gearshifts.

Detailed description of a preferred embodiment

[0017] In a preferred embodiment, the method of the invention is implemented in order to generate a pedal output signal of an accelerator pedal in such a way that engine speed flares may be reduced or avoided during gearshifts.
Therefore, in this preferred embodiment, under given conditions, a given absolute variation in the pedal output signal is produced by a shorter accelerator pedal displacement when the accelerator pedal is released than when it is depressed. The expression "absolute variation" here means the absolute value of the variation, i.e. the value of the variation inde-

pendently of its sign. It follows that a pedal output signal indicating an entirely released pedal, i.e. an idle output signal, may be generated before the accelerator pedal has been entirely released. It also means that, under given conditions, a different pedal output signal is generated for a same pedal position depending on whether the accelerator pedal has been depressed or released.

In the present method, the pedal output signal is preferably generated according to an acceleration function (face) or to a deceleration (f_{dec}), depending on the situation. An example for such acceleration and deceleration functions is shown in Fig. 1, where each of the functions is represented by a straight line.Numerical examples will be used for a better understanding of this preferred embodiment of the method of the invention.

The accelerator pedal has a pedal position (PP) assumed to range from 0 to 100%. For an entirely released accelerator pedal, PP=0%. For an entirely depressed accelerator pedal, PP=100%. The pedal output signal (POS) is also assumed to range from 0 to 100%. A pedal output signal of 0% corresponds to an idle output signal. POS=100% brings the engine to full load.

In the present example, the functions are defined as follows:

$$f_{acc}(PP) = PP,$$

and

$f_{dec}(PP) = S(PP - PO)$, where S (S>1) is the slope of the straight line and PO is the pedal offset.

[0018] When the accelerator pedal is entirely released, the pedal output signal and the pedal position are identical, since an idle output signal has to be generated when the pedal is entirely released. If the accelerator pedal is then depressed, the pedal output signal is given by the acceleration function (POS = f_{acc}(PP)), thus POS and PP stay identical. This can be seen on Fig.1 where the pedal output signal is plotted versus the pedal position, and f_{acc} is indicated by reference sign A whereas f_{dec} is indicated by reference sign D.

[0019] Let us now assume that the accelerator pedal is depressed until the pedal position reaches e.g. 50%, and that it is subsequently released from that position, which shall be called switch position. Then, in accordance with the present method, the pedal output signal shall be given by the deceleration function. This means that the pedal output signal was given by f_{acc} and that consequently to the release of the pedal, the pedal output signal is then given by f_{dec}. More generally, this condition shall be respected every time the pedal is released while the pedal output signal is given by f_{acc}.

[0020] As can be seen in Fig.1, the deceleration function is steeper than the acceleration function. Hence, a pedal output signal of 0%, i.e. idle output signal, will be obtained before the accelerator pedal is entirely released. This introduces an offset in the position of the accelerator pedal, which is clear in view of Fig.1. From the equation of f_{dec}, it is also clear that f_{dec} equals 0% when the pedal position reaches an offset pedal position equal to PO, which shall be called offset pedal position. In practice, the slope of the deceleration function is a constant. It is preferably about 10% steeper than the slope of the acceleration function. However, in this embodiment, the slope has been set to 1.4 (i.e. 40% steeper) in order to exaggerate the effect of the method. As understood, the pedal offset depends on the switch position and is needed to obtain the equation of the deceleration function. Hence the pedal offset is calculated as soon as a release of the pedal is detected and a transition from face to f_{dec} should be performed. The value of PO is obtained by equating f_{acc} to f_{dec} at the switch position (50%), which yields the following pedal offset:

$$PO = \frac{(S-1)}{S} * PP$$

[0021] In the present example, S=1.4 and PP=50%, thus PO=14.3 % and offset pedal position = 14.3 % as well.

[0022] So, if the pedal is released from the switch position, the pedal output signal is generated according to the deceleration function. As a matter of fact, the pedal output signal is advantageously given by f_{dec} as long as the pedal position is between the switch position and the offset pedal position. This ensures a coherent control of the pedal and the continuity of the pedal output signal. Indeed, if f_{acc} was only used for depressed pedals and f_{dec} for released pedals, there would be evident discontinuities in the values of the pedal output signal.

[0023] Hence, if the pedal is released from the switch position (50%) to e.g. PP=40%, then POS is given by f_{dec}. If the pedal is again depressed from PP=40%, then POS is still given by f_{dec}, until it reaches f_{acc}. In other words, if the pedal has been released and is subsequently depressed, the pedal output signal is given by f_{dec} until it reaches the pedal output signal that would be given by f_{acc}, and the pedal output signal is then further generated according to f_{acc}.

[0024] Now, if the pedal is released from the switch position to the offset pedal position, then the pedal output signal is 0% (idle output signal), since f_{dec}(offset pedal position)=0%. It will be understood that if the pedal is further released, the pedal output signal should still be 0%. Therefore, the deceleration function is advantageously shifted (parallel shift) to the current pedal position (i.e. towards decreasing pedal positions) as long as the pedal position decreases so that an idle output signal can be generated. The translation may be carried out by modifying the variable PP in the deceleration function f_{dec} by a value corresponding to the pedal displacement between the offset pedal position and the current pedal position. For example, if the pedal is decreased to 7.5%, then POS shall be given by f_{dec}(PP+(14.3-7.5)). In the present embodiment, the same result can be achieved by giving PO the value of the current pedal position.

[0025] If the pedal is now again depressed from PP=7.5%, then the pedal output signal should be given by the translated deceleration function calculated at that position, i.e. POS=f_{dec}(PP+(14.3-7.5)). This translated f_{dec} is indicated by reference sign D' in Fig.1. It allows the generation of a coherent pedal output signal since the pedal output signal thus varies as with the initial deceleration function. When f_{dec}(PP+(14.3-7.5)) reaches facc(PP) then the pedal output signal is again given by $f_{acc,}$ as previously explained.

[0026] A convenient way to implement the present method is to adapt it for an on-board computer. The preferred flowchart for programming the method is shown in Fig.2. At 10 the pedal position is compared to the old pedal position in order to detect acceleration or deceleration. When depressing the pedal for the first time, i.e. from 0%, f_{dec} is not in use and as long as the pedal is depressed the comparison at 10 yields YES. Therefore, the pedal output signal is generated according to the acceleration function, as shown at 12: pedal output signal = pedal position.

[0027] If the pedal is depressed to PP=50% and then released (switch position), then the answer to the test at 10 is NO. At that moment, the deceleration function is not yet in use (13) and the pedal offset is to be calculated first, as shown at 14. Then, f_{dec} is set in use and the pedal output signal is calculated at 16.

[0028] As long as the pedal position is between the offset pedal position and the pedal position of the switch position, the answer to the test at 13 is YES and the pedal output signal is given by f_{dec} as previously calculated. For example, if the pedal is released from the switch position to 40% and subsequently depressed, then the test at 10 yields YES and POS = f_{dec}(PP), see 20. If the pedal position increases above the switch position, then the pedal output signal given by f_{dec} is greater than the pedal position (more generally to the pedal output signal that would be given by f_{acc}). Hence, as imposed after the test at 22, the deceleration function is disabled and the pedal output signal is given by f_{acc}, as shown at 24.

[0029] Now, if the pedal is released from the switch position (50%) to the offset pedal position and further to a pedal position below e.g. 7.5%, then the test at 18 yields YES and Pedal Offset is given the value of the current pedal position, 26, so that an idle output signal may be generated by f_{dec}. As f_{dec} is a straight line, directly modifying the Pedal Offset is equivalent to shifting the deceleration function by a value corresponding to (offset pedal position - pedal position). The following points are clear from Fig.2:

- if f_{acc} is in use and pedal position < old pedal position then f_{dec} is set in use;
- if pedal position>old pedal position and f_{dec} is in use, then as soon as f_{dec}(pedal position) reaches f_{acc}(pedal position) the deceleration function is disabled and the pedal output signal given by f_{acc}.

[0030] In Fig.3 and Fig.4, graphs representing the pedal position (continuous lines) and the resulting pedal output signal (dashed lines) are shown. On these graphs, the vertical axis represents the percentage of pedal position, resp. of pedal output signal. The horizontal axis indicates the time in ms, the origin of time being arbitrary.

[0031] In Fig.3, each peak corresponds to a gearshift. When the pedal is depressed from 0% then POS = f_{acc}(PP). Therefore in the increasing part of the peak the pedal output signal equals the pedal position. Next, as the pedal is released while f_{acc} was in use, the deceleration function is used.

[0032] For the first two peaks, as indicated by the continuous line, the driver did entirely release the accelerator pedal. During the decreasing part of the curve f_{dec} is used and the pedal output signal anticipates the pedal position.

[0033] The decreasing part of the second peak is shown in Fig.4. The present method permits, in this example, to reach the idle output signal (0%) 32 ms before the accelerator pedal is entirely released. It follows that engine speed flares can be reduced during gearshifts since an idle output signal is generated before the pedal has been entirely released.

[0034] Turning back to Fig.3, the third peak is characteristic of a "driver mistake" which can be corrected with the present method. As can be seen, the driver did not entirely release the accelerator pedal. However, the driver did release the pedal to PP=10%, which is below the offset pedal position, and therefore an idle output signal is generated. Indeed, the pedal has been decreased from about 75%, hence the pedal offset is PO=(1.4-1)/1.4*75=21.4%=offset pedal position.

Claims

1. A method for generating a pedal output signal indicative of the position of an accelerator pedal to be used for electronic load control of an internal combustion engine, wherein, under given conditions, a given absolute variation in said pedal output signal is produced by a different accelerator pedal displacement depending on whether the

accelerator pedal is depressed or released, wherein said pedal output signal may be generated according to an acceleration function and, if said pedal output signal is generated according to said acceleration function and indicates a depressed pedal position, then if said accelerator pedal is released, said pedal output signal is generated according to a deceleration function **characterized in that** said deceleration function generates a pedal output signal indicating an entirely released pedal position when the pedal is released to an offset pedal position different from the entirely released pedal position.

2. The method according to claim 1, **characterized in that** if said accelerator pedal is further released from said offset pedal position then said deceleration function is translated so as to generate an idle signal output for the actual pedal position.

3. The method according to claim 2, **characterized in that** if said accelerator pedal has been released, then if said accelerator pedal is depressed said pedal output signal is generated according to said deceleration function or to a translation thereof;
and **in that**, if said pedal output signal generated according to said deceleration function or translated deceleration function reaches the pedal output signal that would be generated according to said acceleration function, then said pedal output signal is generated according to said acceleration function.

4. The method according to claim 3, **characterized in that** if said accelerator pedal has been released from the offset pedal position to a given pedal position and if said accelerator pedal is subsequently depressed, then the pedal output signal is generated according to said deceleration function translated by a value corresponding to the difference between said offset pedal position and said given pedal position.

5. The method according to any one of claims 1 to 4, **characterized in that** said acceleration function is of the form: f_{acc}(pedal position) = A1*pedal position, with f_{acc}(entirely released pedal position)=idle output signal; and the deceleration function is of the form:

f_{dec}(pedal position) = A2*(pedal position-pedal offset), with A2>A1 and
f_{dec}(offset pedal position)=idle output signal .

Patentansprüche

1. Verfahren zur Erzeugung eines Pedalausgangssignals, das für die Stellung eines Fahrpedals, für die elektronische Belastungssteuerung eines Verbrennungsmotors zu verwendenden darstellend ist, wobei, unter vorgegebenen Bedingungen, eine gegebene absolute Änderung des Pedalausgangssignals durch einen unterschiedlichen Fahrpedalbetätigungsweg erzeugt wird, und zwar je nachdem, ob das Fahrpedal gedrückt oder freigegeben wurde, wobei das Pedalausgangssignal gemäß einer Beschleunigungsfunktion erzeugt werden kann und, wenn das Pedalausgangssignal gemäß der Beschleunigungsfunktion erzeugt wird und eine gedrückte Pedalstellung darstellt, dann wenn das Fahrpedal freigegeben wird, das Pedalausgangssignal gemäß einer Verzögerungsfunktion erzeugt wird, **dadurch gekennzeichnet, dass** die Verzögerungsfunktion ein Pedalausgangssignal erzeugt, das eine vollständig freigegebene Pedalstellung darstellt, wenn das Pedal bis auf eine Offsetpedalstellung freigegeben wird, die sich von der vollständig freigegebenen Pedalstellung unterscheidet

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** dann wenn das Fahrpedal von der Offsetpedalstellung aus noch weiter freigegeben wird, die Verzögerungsfunktion so verschoben wird, dass ein Leerlaufsignalausgang für die tatsächliche Pedalstellung erzeugt wird

3. Verfahren nach Anspruch 2, **dadurch gekennzeichnet, dass** wenn das Fahrpedal freigegeben wurde, dann wenn das Fahrpedal gedrückt wird, das Pedalausgangssignal gemäß der Verzögerungsfunktion oder einer Translation derselben erzeugt wird; und dass, wenn das gemäß der Verzögerungsfunktion oder verschobenen Verzögerungsfunktion erzeugte Pedalausgangssignal das Pedalausgangssignal erreicht, das gemäß der Beschleunigungsfunktion erzeugt würde, dann das Pedalausgangssignal gemäß der Beschleunigungsfunktion erzeugt wird

4. Verfahren nach Anspruch 3, **dadurch gekennzeichnet, dass** wenn das Fahrpedal von der Offsetpedalstellung aus bis auf eine gegebene Pedalstellung freigegeben wurde und das Fahrpedal anschließend gedrückt wird, dann das Pedalausgangssignal gemäß der Verzögerungsfunktion erzeugt wird, die um einen Wert verschoben wurde, der der Differenz zwischen der Offsetpedalstellung und der gegebenen Pedalstellung entspricht

5. Verfahren nach einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet, dass** die Beschleunigungsfunktion die folgende Form aufweist: f_{acc}(Pedalstellung) = A1*Pedalstellung, wobei f_{acc}(vollständig freigegebene Pedalstellung)=Leerlaufausgangssignal; und die Verzögerungsfunktion die folgende Form aufweist:

   f_{dec}(Pedalstellung) = A2*(Pedalstellung-Pedaloffset), wobei A2>A1 und f_{dec}(Offsetpedalstellung)=Leerlaufausgangssignal.

Revendications

1. Procédé de génération d'un signal de sortie de pédale indicatif de la position d'une pédale d'accélérateur à utiliser pour la commande électronique de charge d'un moteur à combustion interne, dans lequel dans des conditions données, une variation absolue donnée dudit signal de sortie de pédale est produite par un déplacement différent de la pédale d'accélérateur selon que l'on enfonce la pédale d'accélérateur ou qu'on la relâche, dans lequel ledit signal de sortie de pédale peut être généré selon une fonction d'accélération et, si ledit signal de sortie de pédale est généré selon ladite fonction d'accélération et indique une position de pédale enfoncée, alors si ladite pédale d'accélérateur est relâchée, ledit signal de sortie de pédale est généré selon une fonction de décélération, **caractérisé en ce que** ladite fonction de décélération génère un signal de sortie de pédale indiquant une position de pédale entièrement relâchée lorsque la pédale est relâchée à une position de pédale décalée différente de la position de pédale entièrement relâchée

2. Procédé selon la revendication 1, **caractérisé en ce que** si ladite pédale d'accélérateur est encore relâchée de ladite position de pédale décalée, alors ladite fonction de décélération est translatée de manière à générer une sortie de signal de ralenti pour la position de pédale réelle

3. Procédé selon la revendication 2, **caractérisé en ce que** si ladite pédale d'accélérateur a été relâchée, alors si ladite pédale d'accélérateur est enfoncée, ledit signal de sortie de pédale est généré selon ladite fonction de décélération ou une translation de celle-ci ;
   et **en ce que**, si ledit signal de sortie de pédale généré selon ladite fonction de décélération ou ladite fonction de décélération translatée atteint le signal de sortie de pédale d'accélération qui serait généré selon ladite fonction d'accélération, alors ledit signal de sortie de pédale est généré selon ladite fonction d'accélération

4. Procédé selon la revendication 3, **caractérisé en ce que** si ladite pédale d'accélérateur a été relâchée de la position de pédale décalée à une position de pédale donnée et si ladite pédale d'accélérateur est ensuite enfoncée, alors le signal de sortie de pédale est généré selon ladite fonction de décélération translatée d'une valeur correspondant à la différence entre ladite position de pédale décalée et ladite position de pédale donnée

5. Procédé selon l'une quelconque des revendications 1 à 4, **caractérisé en ce que** ladite fonction d'accélération a la forme suivante :

   f_{acc}(position pédale) = A1*position pédale, avec f_{acc} (position pédale entièrement relâchée) = signal de sortie de ralenti ; et la fonction de décélération a la forme suivante :
   f_{dec} (position pédale) = A2*(position pédale - décalage pédale), avec A2>A1 et
   f_{dec} (position pédale décalée) = signal de sortie de ralenti.

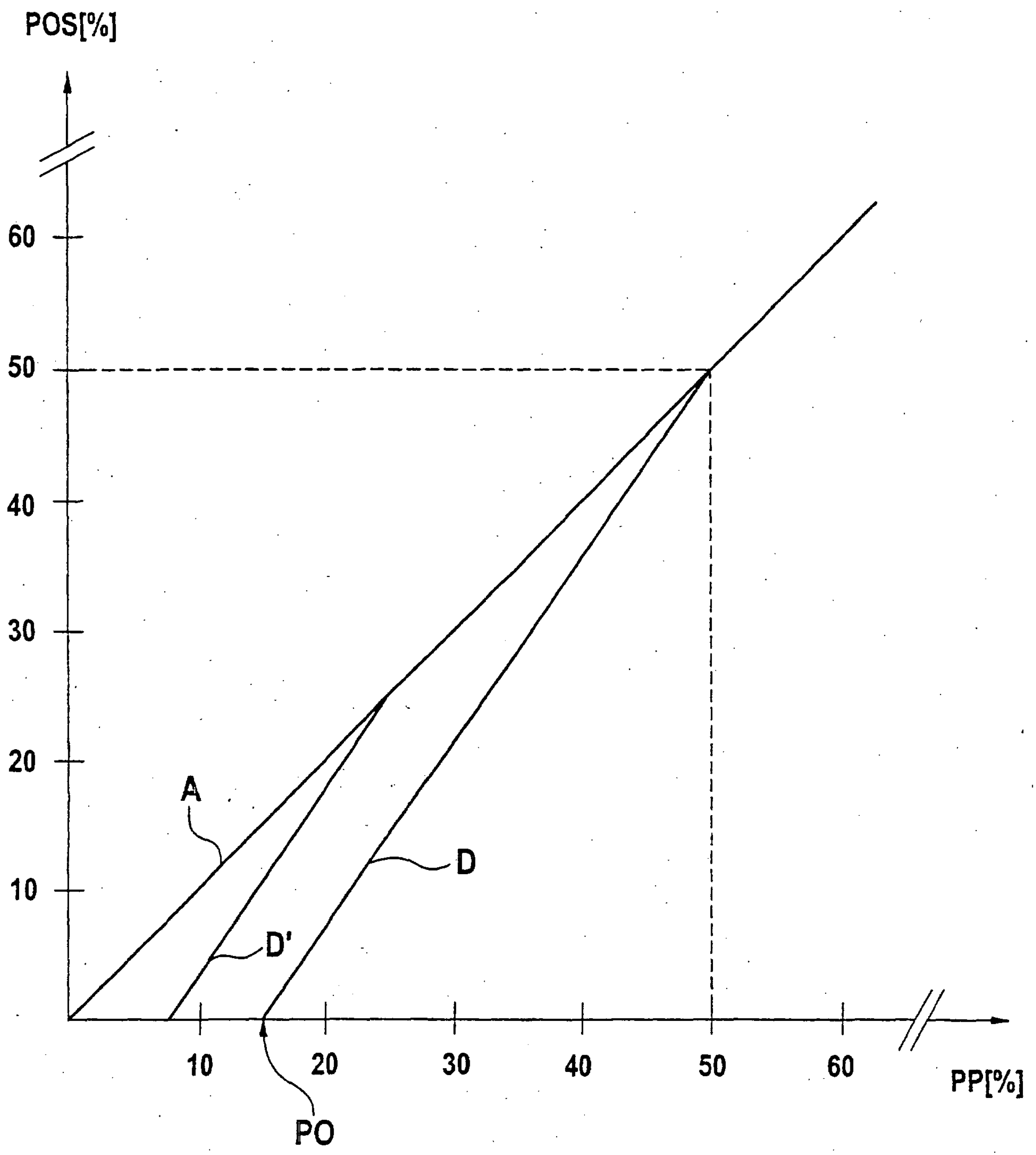


Fig. 1

Fig. 2

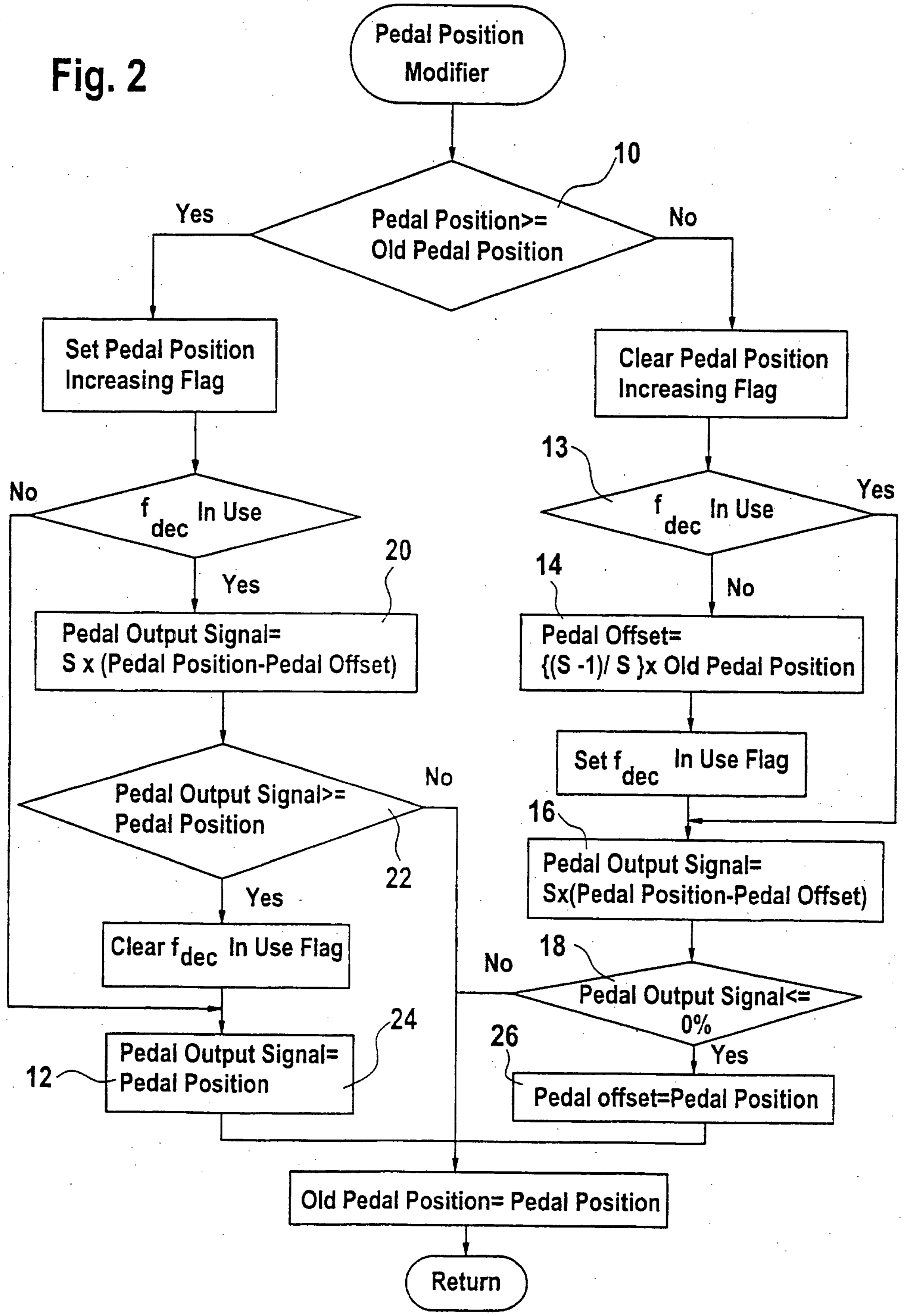

Pedal Position Modifier
10
Pedal Position>= Old Pedal Position
Yes
No
Set Pedal Position Increasing Flag
Clear Pedal Position Increasing Flag
13
f dec In Use
No
Yes
Yes
No
20
14
Pedal Output Signal= S x (Pedal Position-Pedal Offset)
Pedal Offset= {(S -1)/ S }x Old Pedal Position
Set f dec In Use Flag
Pedal Output Signal>= Pedal Position
No
22
16
Pedal Output Signal= Sx(Pedal Position-Pedal Offset)
Yes
Clear f dec In Use Flag
18
No
Pedal Output Signal<= 0%
Yes
24
26
12
Pedal Output Signal= Pedal Position
Pedal offset=Pedal Position
Old Pedal Position= Pedal Position
Return

Fig. 3

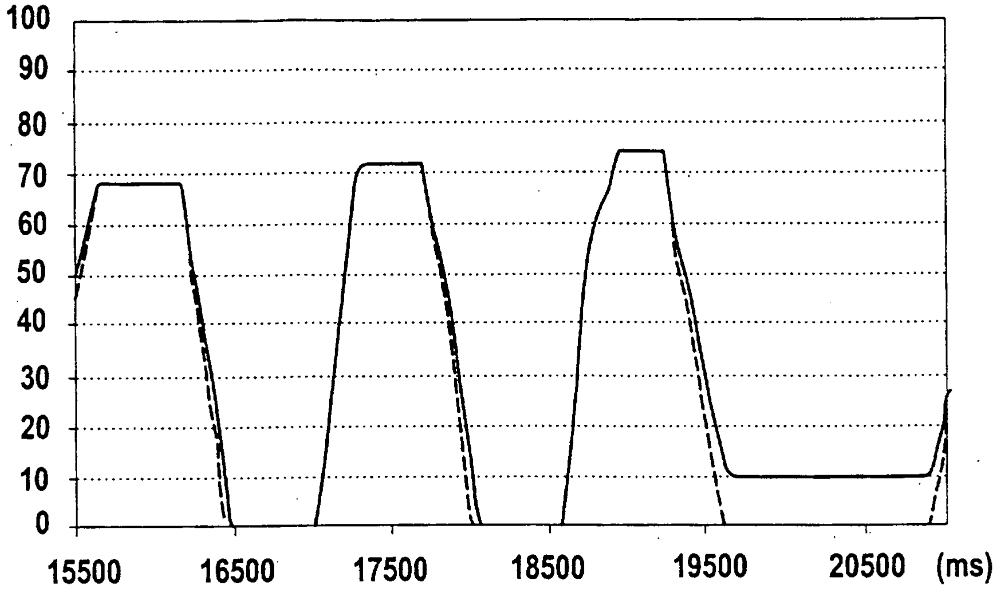
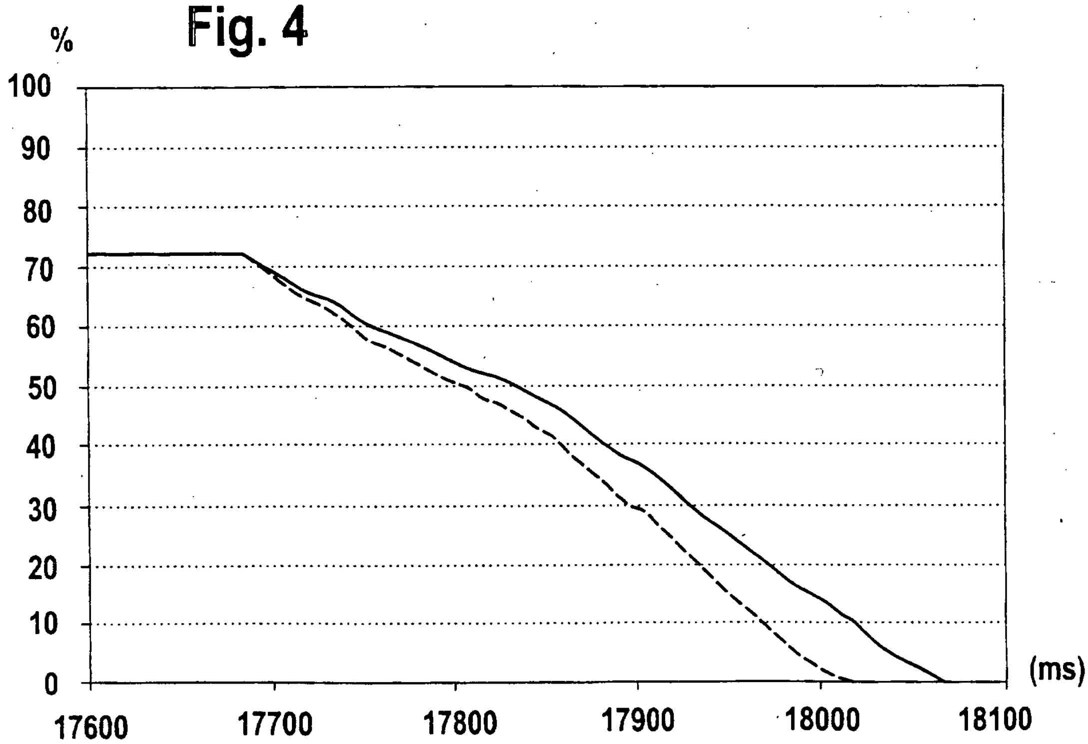

100
90
80
70
60
50
40
30
20
10
0
15500
16500
17500
18500
19500
20500
(ms)

Fig. 4


%
100
90
80
70
60
50
40
30
20
10
0
17600
17700
17800
17900
18000
18100
(ms)