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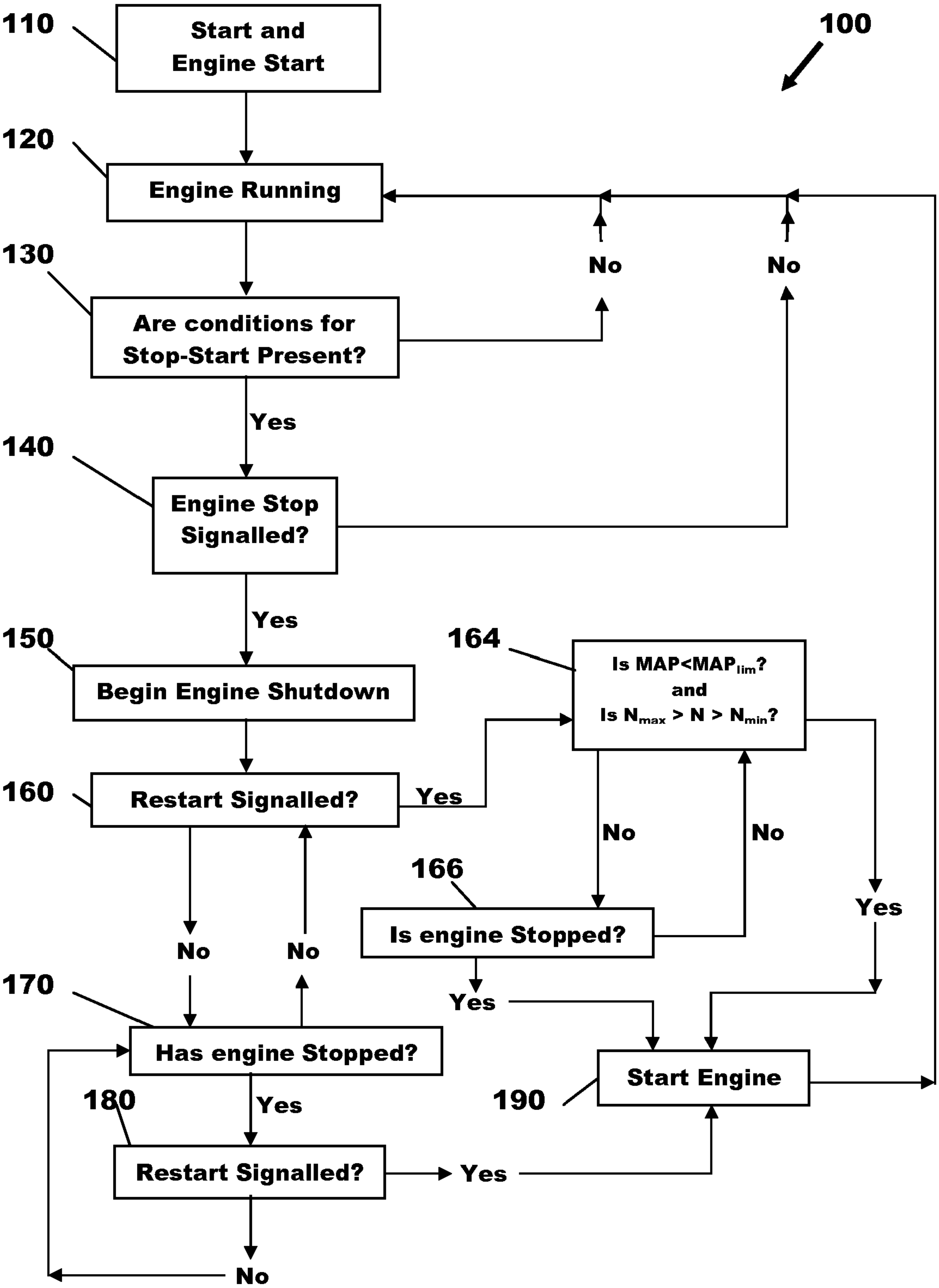
100
110
Start and
Engine Start
120
Engine Running
130
Are conditions for
Stop-Start Present?
No
No
Yes
140
Engine Stop
Signalled?
Yes
150
Begin Engine Shutdown
164
Is MAP<MAP$_{lim}$?
and
Is N_{max} > N > N_{min}?
160
Restart Signalled?
Yes
No
No
166
Is engine Stopped?
Yes
No
No
170
Yes
Has engine Stopped?
Yes
180
Restart Signalled?
Yes
190
Start Engine
No

Fig.1

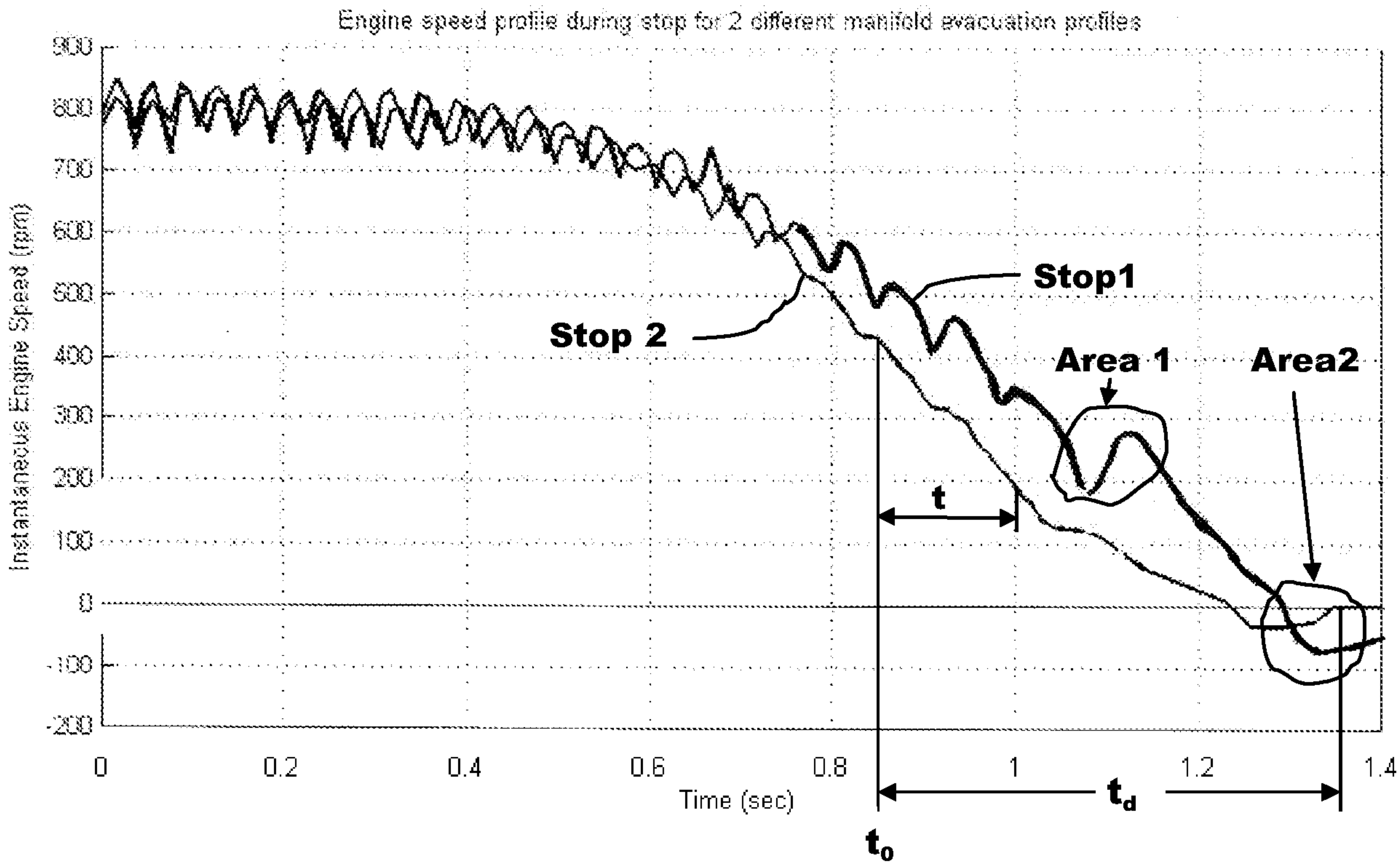
Engine speed profile during stop for 2 different manifold evacuation profiles
Instantaneous Engine Speed (rpm)
900
800
700
600
500
400
300
200
100
0
-100
-200
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Time (sec)
Stop1
Stop 2
Area 1
Area2
t
t0
td

Fig.2a

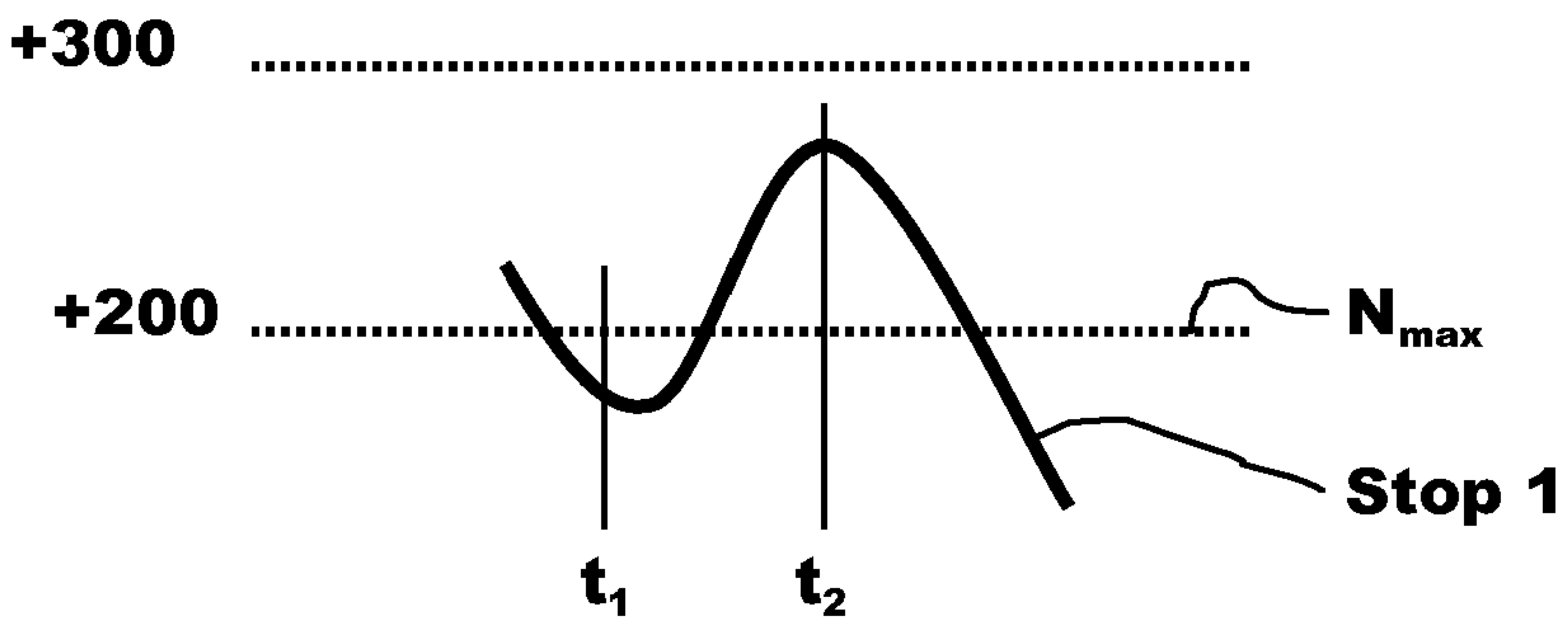
+300
+200
Nmax
Stop 1
t1
t2

Fig.2b

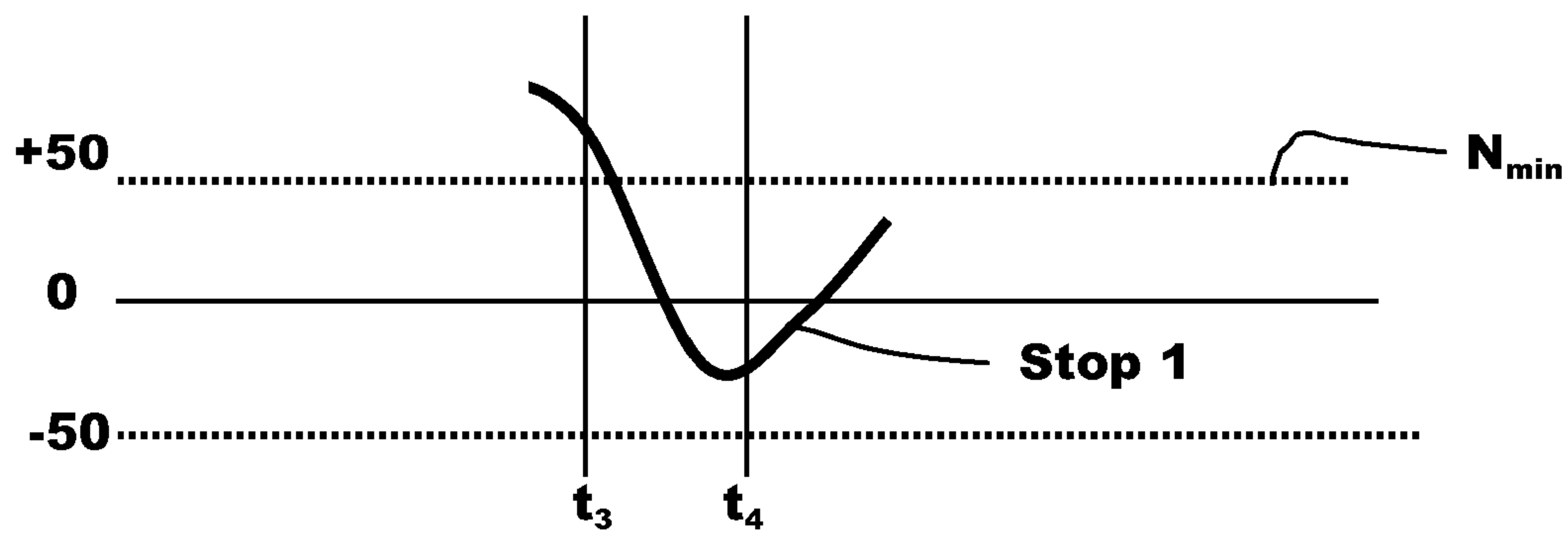
+50
0
-50
N_{min}
Stop 1
t_3
t_4

Fig.2c

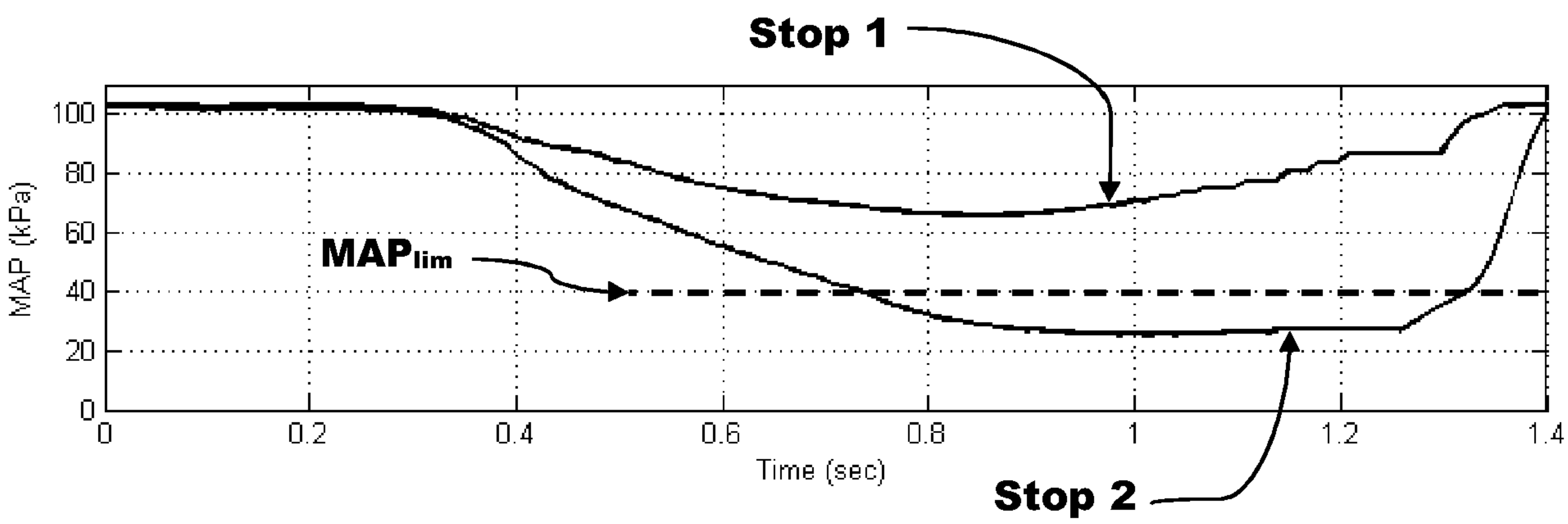
Stop 1
MAP (kPa)
100
80
60
40
20
0
MAP_{lim}
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Time (sec)
Stop 2

Fig.3

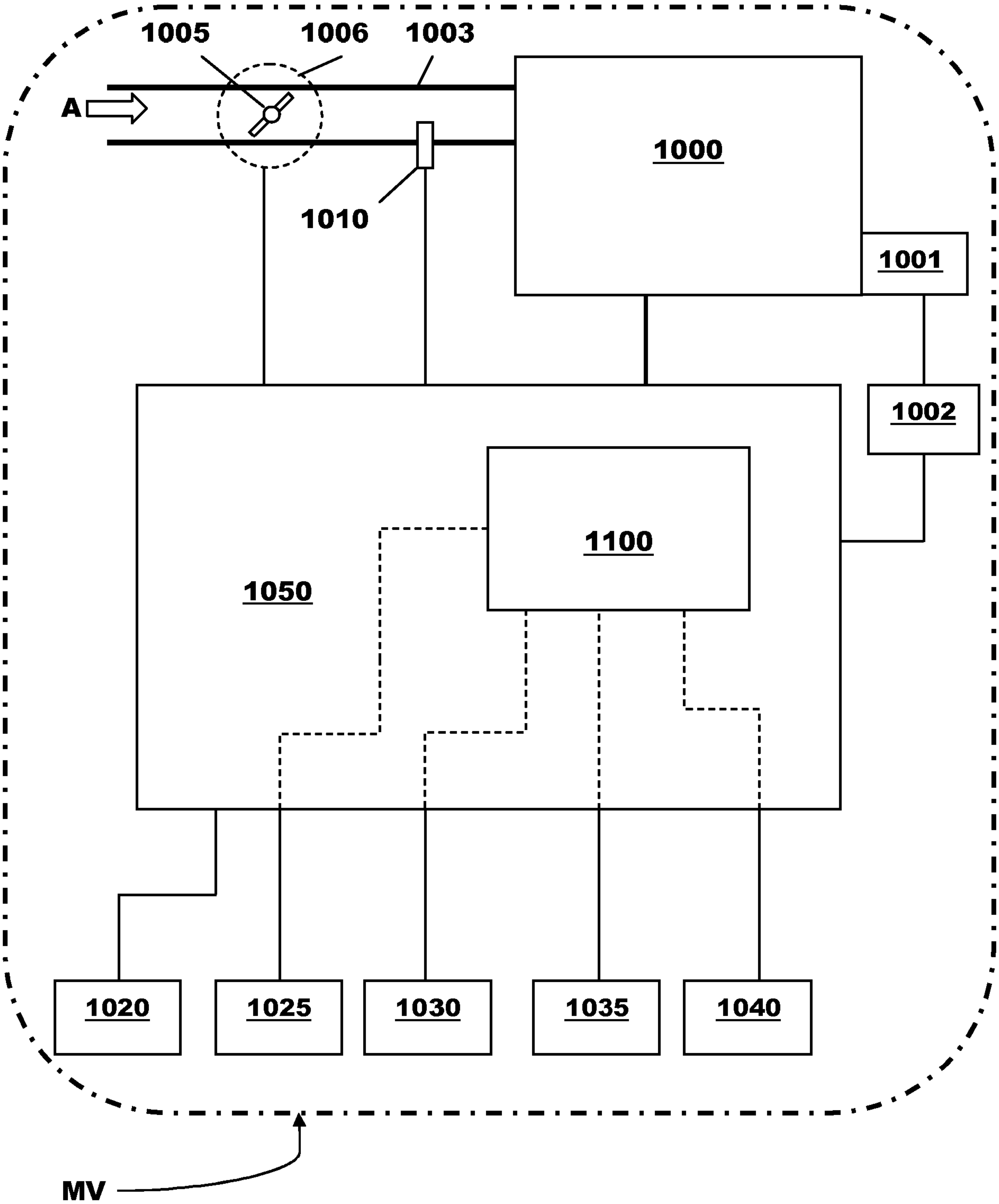
1005
1006
1003
A
1000
1010
1001
1002
1100
1050
1020
1025
1030
1035
1040
MV

Fig.4

A Method of Controlling the Stopping and Starting of an Engine of a Motor Vehicle

This invention relates to a motor vehicle having an engine and, in particular, to the control of the stopping and starting of the engine by a stop-start controller.

It is known to provide a motor vehicle with a stop-start control system for automatically stopping and starting an internal combustion engine used to provide motive power for the motor vehicle.

A stop-start system automatically stops the engine whenever it is determined based partially upon driver actions that there is an opportunity to do so in order to improve fuel consumption and reduce emissions from the engine.

Various driver actions can be used to affect stopping and starting of the engine depending upon whether the system is applied to a manual transmission or an automatic transmission. In the case of a manual transmission two common control modes are often referred to as “stop in-gear” and “stop in neutral”.

It is not uncommon for a driver ‘change of mind’ to occur during the period following a decision to stop the engine but before the engine has actually stopped. A change of mind may result from an unexpected change in traffic conditions or because the driver has inadvertently changed the state of one or more driver operable control devices such that the system logic acts to re-start the engine.

In a ‘change of mind’ event it is desirable to re-start the engine of a vehicle equipped with stop-start technology in the minimum amount of time possible. In order to achieve this, a starter motor pinion may need to be engaged with a ring gear before the latter has completely stopped rotating in order to reduce the delay in restarting the engine.

The range of instantaneous engine speeds at which the starter motor can be engaged without damage occurring to the starter motor or the ring gear is dependent on the design of the electrical and mechanical components, but is typically in the order of 200Rpm when the engine is rotating in a forwards or normal direction. Engagement of the starter motor when the engine is rotating in a reverse direction is to be avoided if possible due to the high probability of damage occurring.

The time taken from the point that engagement is initiated to the point where a pinion of the starter motor first contacts a ring gear attached to a flywheel of the engine (the pinion travel time) is also dependent on electrical and mechanical design of the starter motor, wiring and power supply as well as environmental and aging factors such as temperature, battery state of charge and starter contamination. This pinion travel time may be of the order of a few tens of milliseconds such as, for example, 50ms.

It is known that the speed profile of a stopping engine is highly non-linear and that the instantaneous acceleration of the crankshaft can be such that the instantaneous speed can vary during the pinion travel time by a similar order of magnitude to the range of permitted speeds for starter engagement. To engage the starter motor pinion at the correct speed is therefore a significant challenge and normally the solution is to wait until the engine is stationary before the engine starter motor is engaged.

The average deceleration during an engine run down is primarily due to friction and other loads on the engine dissipating kinetic energy. Any speed oscillations and possible reverse running are primarily due to energy being stored and released as the engine continues to go through its compression cycle during shut-down.

A known strategy to try and reduce oscillations during shut-down is to close an intake throttle valve during the run down phase. This greatly reduces the air that can be drawn into the cylinders of the engine to be compressed and expanded and reduces the absolute air pressure in the intake manifold as the engine 'pumps out' the air downstream of the intake throttle valve.

It is an object of the invention to provide an improved method for dealing with a change of mind event during an engine shut-down.

According to a first aspect of the invention there is provided a method of controlling the stopping and starting of an engine comprising initiating an engine shut-down and closing a throttle valve in an inlet manifold of the engine when an engine shut-down is signalled and using a starter device to restart the engine during the shut-down if starting is signalled, the engine speed is within predefined upper and lower limits and an absolute pressure in the inlet manifold of the engine is below a predefined limit.

The method may further comprise automatically closing the throttle valve in the inlet manifold when an engine shut-down is signalled.

An engine shut-down may be signalled when a predefined combination of control variables is present.

Restarting of the engine may be signalled if the state of at least one control variable changes to a state indicating that the engine should be started.

The starter device may be one of a starter motor having a pinion for engagement with a ring gear to start the engine and a belt drive integrated starter generator.

According to a second aspect of the invention there is provided a control system for an engine of a motor vehicle having an inlet manifold in which is mounted a throttle valve to vary the flow of air to the engine wherein the system comprises a control module, a pressure sensor to sense the absolute pressure in an inlet manifold of the engine downstream from the throttle valve, a number of inputs to the control module providing signals indicative of when the engine should be stopped and started and the speed of the engine, an actuator for the throttle valve and a starter device for starting the engine, the control module being operable to initiate an engine shut-down and close the throttle valve in the inlet manifold of the engine when the inputs indicate that an engine shut-down is signalled and is further operable to restart the engine using the starter device during the shut-down if the inputs indicate that starting is signalled, the engine speed is between predefined upper and lower limits and the absolute pressure sensed by the pressure sensor indicates that the absolute pressure in the inlet manifold of the engine is below a predefined limit.

An engine shut-down may be signalled when the inputs indicate that a predefined combination of control variables is present.

Restarting of the engine may be signalled if the inputs indicate that the state of at least one control variable changes to a state indicating that the engine should be started.

The starter device may be one of a starter motor having a pinion for engagement with a ring gear to start the engine and a belt drive integrated starter generator.

According to a third aspect of the invention there is provided a motor vehicle having an engine having an inlet manifold in which is mounted a throttle valve and a control system constructed in accordance with said second aspect of the invention.

The invention will now be described by way of example with reference to the accompanying drawing of which:-

Fig.1 is a high level flow chart of a method of controlling an engine according to a first aspect of the invention;

Fig.2a is a graph showing the relationship between engine speed and time for two exemplary engine shut-downs;

Fig.2b and 2c are portions of the graph shown in Fig.2a on an enlarged scale;

Fig.3 is a graph showing the relationship between absolute manifold pressure and time for the two engine shut-downs shown in Fig.2; and

Fig.4 is a schematic diagram of a motor vehicle according to a third aspect of the invention having a control system according to a second aspect of the invention.

With reference to Fig.1 there is shown a high level flow chart of a method 100 of controlling the stopping and starting of an engine such as the engine 1000 shown in Fig.4.

The method starts at box 110 which are key-on and manual engine start steps performed by a user of a motor vehicle MV to which the engine 1000 is fitted.

The method then advances to box 120 where the engine is running. Then in box 130 it is tested whether the conditions for stop-start operation are present. For example and without limitation, is the temperature of the engine coolant above a predefined temperature or is there sufficient charge in a battery to guarantee restarting.

If these conditions are not met then the engine cannot be stopped even if an opportunity for stopping it arises and the method loops around boxes 130 and 120 until either the conditions are met or a key-off event occurs causing the method to end.

If in box 130 the conditions are met then the method advances to box 140 where it is checked to see whether an engine stop is signalled by the actions of the driver. Various combinations could be used to signal that an engine stop is required but in the case of this example for a vehicle having an automatic transmission, if the motor vehicle MV is stationary and an accelerator pedal is not being pressed and a brake pedal is being pressed then this is used to indicate that the engine should be stopped.

If an engine stop is not signalled the method returns to box 120 but, if an engine stop is signalled, the method advances to box 150.

In box 150 the engine shut-down commences. Various means of shutting down an engine are known but generally, in the case of a diesel engine, the fuel supply is terminated and, in the case of a gasoline engine, the sparking plugs are switched off and the fuel supply is cut. However, one key action that takes place irrespective of engine type is the shutting of a throttle valve in an air inlet of the engine. This is normally done automatically via a signal from an engine controller or other control unit but in the case of a gasoline engine it is possible for the closing to be done in response to the actions of a driver on an accelerator pedal. That is to say, because one of the conditions for determining whether the engine should be shut-down is that the accelerator pedal is not being pressed this will result in the throttle valve being closed and so there is theoretically no requirement for automatic intervention. However, automatic closing of the throttle valve is preferred because it eliminates the risk of the driver manipulating the accelerator pedal during the engine shut-down.

Following on from box 150, in box 160 there is a "change of mind" intervention during the shut-down of the engine. That is to say, during the engine shut-down the driver has removed their foot from the brake pedal which is the change of state required to signal an engine restart.

If there is a "change of mind" in box 160 the method advances from box 160 to box 164.

In box 164 it is tested to see whether it is safe to engage a starter motor to start the engine.

The test in box 164 comprises two parts:-

a/ Is the current instantaneous engine speed (N) within a speed range defined by predefined upper and lower speed limits N_{max} and N_{min} . That is to say, is $N_{max}>N>N_{min}$?

and

b/ Is the absolute pressure (MAP) downstream of the throttle valve in the air inlet to the engine lower than a

predefined pressure limit MAP_{lim}.
That is to say, is MAP < MAP_{lim}?

For starting to commence both of these tests have to be passed.

In the case of one exemplary engine, the upper speed limit N_{max} was 200 Rpm, the lower speed limit Nmin was 50 Rpm and the absolute pressure limit was 40 kPa. It will however be appreciated that these are provided by way of example and that other values could be used for different engine and starter motor configurations.

If both of the tests are passed then the method advances to box 190 and the engine is started using the starter motor and the method then returns to box 120 with the engine running.

If one or both of the tests are failed in box 164 then the method loops around boxes 166 and 164 until either the two tests in box 164 have been passed or the engine has stopped rotating. In either case, the method advances to box 190 and then on to box 120 as previously discussed.

Referring back to box 160, if there is no 'change of mind', the method advances to box 170 with the engine stopped and will then loop around boxes 170 and 180 until a restart is signalled in box 180. As before, a restart will be signalled in this case if the driver removes their foot from the brake pedal. If a restart is signalled in box 180, the method advances to box 190 where the engine is started using the starter motor and then returns to box 120 with the engine running.

It will be appreciated that the engine can be immediately started in box 190 because it is stationary. The only time delay in this case being the time taken for a pinion (not shown) of the starter motor to engage with a ring gear (not shown) fitted to a flywheel (not shown) of the engine.

The primary advantage of the invention can best be understood with reference to Figs.2a to 3.

Fig.2a shows two exemplary engine shut-downs referenced as Stop 1 and Stop 2.

In the case of Stop 1 the engine slows during the shut-down but there are large variations in the instantaneous engine speed. This could be due, for example, to the throttle valve not closing fully, late closing of the throttle valve or leakage in the inlet manifold downstream of the throttle valve.

In the case of Stop 2, the engine slows at a similar rate but the variations in instantaneous engine speed are generally insignificant. In this case the throttle valve has closed fully early in the engine shut-down and there are no inlet manifold leaks downstream of the throttle valve.

Fig.3 shows corresponding manifold absolute pressure traces for the Stops 1 and 2 from which it can be seen that the manifold absolute pressure (MAP) is considerably lower in the case of Stop 2 than it is for Stop 1.

Fig.2b shows an Area 1 on Fig.2a on an enlarged scale as it relates to Stop 1. At time t_1 the speed of the engine is below the maximum speed limit N_{max} where the starter motor can be engaged safely and reliably. N_{max} = 200 Rpm in this case. However, at time t_2 which follows t_1 by a short period of time representing the time required for the starter motor to be engaged, the engine speed has risen to a speed greater than N_{max} and in this case to 260 RPM. Therefore in the case of Stop 1 the considerable fluctuations in the instantaneous engine speed would result in a potentially damaging or unreliable starter motor engagement and for this reason starting would need to be delayed until the engine has stopped rotating.

Fig.2c shows an Area 2 on Fig.2a on an enlarged scale as it relates to Stop 1. At time t_3 the speed of the engine is above the minimum speed limit N_{min} where the starter motor can be engaged without significant damage and in a reliable manner. N_{min} = 50 Rpm in this case. However, at time t_4 which follows t_3 by a short period of time representing the time required for the starter motor to be engaged, the engine speed has fallen to a speed less than N_{min} and in this case to minus 25 RPM. Therefore in the case of Stop 1 the considerable fluctuations in the instantaneous engine speed would once again result in a potentially damaging or unreliable starter motor engagement and for this reason starting would need to be delayed until the engine has stopped rotating.

In the case of Stop 2 this would not be the case because there are no significant fluctuations in instantaneous engine speed particularly in the areas of interest for engine starting using a starter motor.

The inventors have therefore deduced that if the engine shut-down is similar to that of Stop 2 then the starter motor can be engaged without significant damage in a reliable manner within a predefined speed range which in this case is set at +200Rpm to +50RPM.

The inventors have also realised that it is possible to predict whether the shut-down is of the Stop 1 type or the Stop 2 type by measuring the absolute pressure (MAP) in the inlet manifold downstream of the throttle valve and setting a limit value (MAP_{lim}) for manifold absolute pressure that must be achieved in order to permit starter motor engagement prior to a full engine stop.

The effect of applying such a technique can be demonstrated with reference to Fig.2a where at time t_0 a “change of mind” engine start is signalled.

If the invention is not used, a time delay t_d is required to allow the engine to come to a stop after which the starter motor can be reliably engaged without damage.

However, if the invention is used, then as soon as the engine speed falls below the upper engine speed limit N_{max} of 200 Rpm, which occurs in this case t seconds after time t_0, engagement of the starter motor can commence.

Therefore the time delay between the signalling of a restart and engagement of the starter motor has been reduced by (t_d-t) seconds which for the example given is 0.4 seconds.

Although this may appear to be an insignificant amount of time in the context of driver impression of the urgency of response to a “change of mind” it is a worthwhile improvement and represents a reduction of 79% in the time delay between the occurrence of the ‘change of mind’ event and the initiation of the starter motor.

With reference to Fig.4 there is shown a motor vehicle MV having an internal combustion engine 1000 and a control system including a system control module 1050.

The engine 1000 is started via a starter motor 1001 having a pinion (not shown) engageable with a ring gear (not shown) fastened to a flywheel (not shown) of the engine 1000. The starter motor 1001 is energised via a starter motor power unit 1002 in response to a signal from the control module 1050.

The engine 1000 has an inlet manifold 1003 in which is mounted an inlet throttle valve 1005 to control the flow of air into the engine 1000. The engine 1000 also includes a number of spark plugs (not shown) and a fuel injection system (not shown) to provide fuel to the engine 1000 as is well known in the art. Operation of the inlet throttle valve 1005 is via an actuator 1006 which is operable in response to a control signal from the control module 1050 to rotate the throttle valve 1005 in the inlet manifold 1003. The throttle valve 1003 varies a flow of air drawn into the engine 1000 in the direction indicated by the arrow "A". When the throttle valve 1005 is fully closed, the engine 1000 will pump the air out of the inlet manifold 1003 downstream of the throttle valve 1003 thereby causing the absolute pressure in the inlet manifold 1003 to fall. The absolute pressure downstream of the throttle valve 1005 is sensed by a manifold absolute pressure sensor 1010 connected to the control module 1050.

The control module 1050 includes in this case a stop-start controller 1100 although it will be appreciated that stop-start controller 1100 could be a separate unit operably connected to the control module 1050.

The control module 1050 has a number of inputs 1020, 1025, 1030, 1035 and 1040 used to control operation of the engine 1000.

The first input 1020 is a schematic representation of a number of inputs relating to the running conditions of the motor vehicle MV such as, for example, engine rotational speed, atmospheric pressure, ambient temperature, exhaust gas constitution, engine coolant temperature, vehicle speed and state of charge of a main battery.

The second input 1025 provides an input indicative of the engagement state of a transmission (not shown) of the motor vehicle MV. Typically this will indicate either whether the transmission is in neutral or in-gear.

The third input 1030 provides an input indicative of the state of an accelerator pedal (not shown) used by a driver of the motor vehicle MV to indicate the required torque to be provided from the engine 1000.

The fourth input 1035 provides an input indicative of the state of a brake pedal (not shown) of the motor vehicle MV. The input 1035 will indicate whether the brake pedal is being pressed or not pressed.

The fifth input 1040 provides an input indicative of the state of a clutch pedal (not shown) of the motor vehicle MV. The input 1040 will indicate whether the clutch pedal is being depressed or not depressed. This input is only required if the motor vehicle MV has a manual transmission using a manually operated clutch pedal to effect engagement and disengagement of a clutch located between the engine 1000 and the transmission. With such an arrangement it is usual to calibrate the movement of the clutch pedal such that, when it can be safely assumed that the clutch is fully disengaged, the clutch pedal is termed ‘depressed’ and when the clutch pedal is not depressed it can be either ‘pressed’ or released. The pressed state is one where the driver has moved the clutch pedal but insufficiently to guarantee that the clutch is fully disengaged.

As is well known in the art the second through fifth inputs 1025 to 1040 can be used by the stop-start controller 1100 in various combinations and various manners to determine when the engine 1000 should be automatically stopped to save fuel and also when it needs to be restarted from the stopped state.

For the purpose of explaining the operation of the control system as it applies to this invention the following control variable states will be assumed for stopping and starting of the engine 1000. However, it will be appreciated that various other combinations of control variable state could be used and that the invention is not limited to the exact combination described hereinafter.

In the case of an engine stop, a stop will be initiated if:-

a/ the transmission is in neutral; and

b/ the clutch pedal is released; and

c/ the brake pedal is pressed; and

d/ the motor vehicle is stationary.

In the case of an engine start, a start will be initiated if:-

e/ the transmission is in neutral;

and either

f/ the clutch pedal state changes from released to any other state;

or

g/ the brake pedal state changes from pressed to released.

Operation of the control system is as follows:-

The control module 1050 continuously monitors the inputs 1020 and the input from the manifold pressure sensor 1010 in order to control normal running of the engine 1000 and controls the throttle valve 1005 via the actuator 1006 to produce the required torque from the engine 1000 and to satisfy any emission requirements for the engine 1000.

The stop-start controller 1100 monitors the inputs from the transmission state sensor 1025, accelerator pedal sensor 1030, brake pedal sensor 1035 and clutch pedal position sensor 1040. It will be appreciated that all of the signals received by the control module 1050 can be shared with the stop-start controller 1100 and vice-versa.

If the stop-start controller 1100 determines that the state of all of the control variables a to d listed above are as required for a shut-down then shut-down of the engine 1000 is signalled in order to save fuel and reduce emissions.

The stop-start controller 1100 then takes the necessary steps to perform the engine shut down which in this case comprise shutting of the fuel supply to the engine 1000, switching off the spark plugs and closing the inlet throttle valve 1005. After these actions have been taken the engine 1000 will begin to stop or run down until after a certain period of time it will have stopped.

From this stopped state the engine will be started if the state of all of the control variables is as given in e to f above. That is to say, if the transmission is in neutral and either the clutch pedal state changes from released to a non-released state (pressed or depressed) or the state of the brake pedal changes from pressed to released then the engine 1000 is started immediately using the starter motor 1001 which is supplied with power by the starter motor power unit 1002 in response to a signal from the control module 1050.

If during the shut-down period there is a change of mind event such as for example, if the clutch pedal state is changed from a released state to a pressed state during the shut-down or the brake pedal state changes from a pressed state to a released state during the shut-down then the engine 1000 must be restarted as soon as possible. However, as previously discussed the starter motor 1001 can only be engaged when certain engine speed conditions are present in order to prevent damage from occurring to the starter motor 1001 and, in particular, to the starter motor pinion and the ring gear on the flywheel.

Therefore before the starter motor 1001 is engaged it is first tested whether the conditions for a safe restart are present. In the case of this invention this test comprises determining whether the engine speed (N) is between an upper speed limit N_{max} and a lower speed limit N_{min} and using the manifold absolute pressure sensor 1010 to sense whether the absolute pressure (MAP) in the inlet manifold 1003 is below a predefined limit MAP_{lim}.

Therefore, if $N_{max} > N > N_{min}$ and $MAP < MAP_{lim}$, the starter motor 1001 is energised by the starter motor power unit 1002 in response to a signal from one of the control module 1050 and the stop-start controller 1100 depending upon the exact construction used.

However, if either the engine speed (N) is not within the predefined speed range bounded by the upper speed limit N_{max} and the lower speed limit N_{min} or the absolute pressure (MAP) in the inlet manifold 1003 is not below the predefined limit MAP_{lim}, the starter motor 1001 is not energised and the control module 1050 will continue to monitor the absolute pressure (MAP) in the inlet manifold 1003 and the engine speed (N).

It will be appreciated that, the engine 1000 may come to a halt before the test conditions to permit restarting have been met. In such a case, the engine 1000 can be immediately restarted because it is then stationary. That is to say, the engine 1000 is only in a shut-down phase requiring limits on restarting while it is rotating.

One of the advantages of the invention is that a delay in response to a “change of mind” can be reduced in a simple manner without the need for complex engine instantaneous speed predictions to be made.

A second advantage of the invention is that all of the hardware required for the invention is already present on most production motor vehicles having stop-start control thereby incurring no additional manufacturing costs.

Although the invention is particularly advantageous where a starter motor having a pinion that has to be engaged with a ring gear to start the engine, the invention also has advantage in the case of a belt drive integrated starter generator (BISG) in a Change of Mind situation.

The high instantaneous accelerations of a 'rough' shutdown of the kind indicated by Plot 1 on Fig.2a potentially produce large variations in belt tension. In some cases it is undesirable to add the tension of a start event to these variations.

For example, the start event and the peak tension due to the fluctuating speed profile could cause excessive belt tension. Alternatively, a start event during a 'trough' in speed might result in low belt tension and the motor load to start excessively low and then step up rapidly when the slack is reduced.

By only using the BISG when it is known that either the engine has halted or the shutdown is a stable, smooth one implied by the presence of low MAP, the tension on the belt is less variable and so fewer problems are likely to arise with the drive belt such as jumping, excessive wear or degradation. A similar control system and operating methodology can be used to that used for the starter motor described above.

It will be appreciated that, if the engine speed at the time the change of mind occurs is above a predefined speed such as, for example 500Rpm, the engine can be restarted in a passive manner utilising stored inertia without the use of any form of starter device

It will be appreciated by those skilled in the art that although the invention has been described by way of example with reference to one or more embodiments it is not limited to the disclosed embodiments and that alternative embodiments could be constructed without departing from the scope of the invention as defined by the appended claims.

Claims

1. A method of controlling the stopping and starting of an engine comprising initiating an engine shut-down and closing a throttle valve in an inlet manifold of the engine when an engine shut-down is signalled and using a starter device to restart the engine during the shut-down if starting is signalled, the engine speed is within predefined upper and lower limits and an absolute pressure in the inlet manifold of the engine is below a predefined limit.

2. A method as claimed in claim 1 wherein the method further comprises automatically closing the throttle valve in the inlet manifold when an engine shut-down is signalled.

3. A method as claimed in claim 1 or in claim 2 wherein an engine shut-down is signalled when a predefined combination of control variables is present.

4. A method as claimed in any of claims 1 to 3 wherein restarting of the engine is signalled if the state of at least one control variable changes to a state indicating that the engine should be started.

5. A method as claimed in any of claims 1 to 4 wherein the starter device is one of a starter motor having a pinion for engagement with a ring gear to start the engine and a belt drive integrated starter generator.

6. A control system for an engine of a motor vehicle having an inlet manifold in which is mounted a throttle valve to vary the flow of air to the engine wherein the system comprises a control module, a pressure sensor to sense the absolute pressure in an inlet manifold of the engine downstream from the throttle valve, a number of inputs to the control module providing signals indicative of when the engine should be stopped and started and the speed

of the engine, an actuator for the throttle valve and a starter device for starting the engine, the control module being operable to initiate an engine shut-down and close the throttle valve in the inlet manifold of the engine when the inputs indicate that an engine shut-down is signalled and is further operable to restart the engine using the starter device during the shut-down if the inputs indicate that starting is signalled, the engine speed is between predefined upper and lower limits and the absolute pressure sensed by the pressure sensor indicates that the absolute pressure in the inlet manifold of the engine is below a predefined limit.

7. A system as claimed in claim 6 wherein an engine shut-down is signalled when the inputs indicate that a predefined combination of control variables is present.

8. A system as claimed in claim 6 or in claim 7 wherein restarting of the engine is signalled if the inputs indicate that the state of at least one control variable changes to a state indicating that the engine should be started.

9. A system as claimed in any of claims 6 to 8 wherein the starter device is one of a starter motor having a pinion for engagement with a ring gear to start the engine and a belt drive integrated starter generator.

10. A motor vehicle having an engine having an inlet manifold in which is mounted a throttle valve and a control system as claimed in any of claims 6 to 9.