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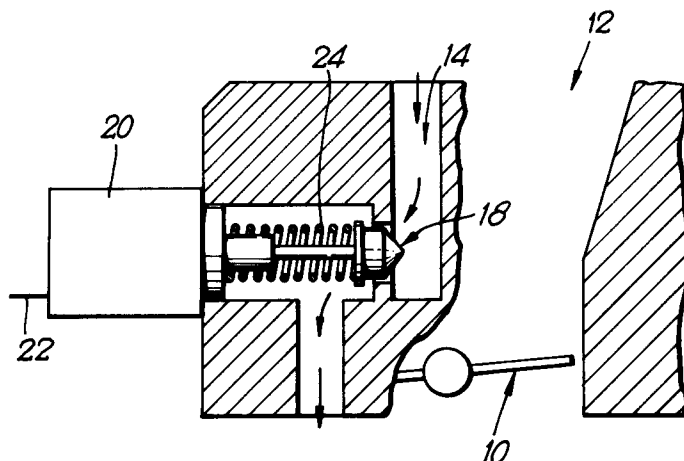
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(54) **Method and apparatus for controlling an air bypass passage.**

(57) Control of the movement of a pintle in an engine, which engine includes a throttle (10) controlling air flow to the engine, a bypass channel (14) bypassing the throttle (10), a pintle (12) controlling the flow of air through the bypass channel (14) and control means (20) controlling the movement of the pintle (18), is effected by determining the position of the throttle (10), determining the position of the pintle (18), determining a desired idling speed on the basis of engine operating conditions, measuring the actual

engine speed; when it is determined that the throttle (10) has moved from an open position to a substantially closed position, controlling the movement of the pintle (18) to a predetermined position at a rate determined by the difference between the actual engine speed and the desired idling speed. Closed loop control of the engine idling speed is enabled after the pintle (18) has reached the predetermined position and engine operating conditions are stable.



The present invention relates to a method of and apparatus for controlling the movement of a pintle of an internal combustion engine, particularly on returning to the idling mode after a perturbation, such as a change in throttle position.

The idling speed of an engine is normally controlled by means of a pintle which is adapted to modify the cross-sectional area of an air channel which bypasses the throttle blade so as to modify the air flow through the bypass passage. The pintle is moved by a stepper motor under the control of an engine idling speed controller, which may be incorporated within an engine management system.

When the engine idling speed controller is active and the throttle blade is in a closed position, the pintle is moved to a position which allows sufficient air flow to cause the engine to operate at a speed which substantially matches a desired engine speed. The desired engine speed is determined on the basis of predetermined engine operating conditions, such as engine coolant temperature, active engine loads, such as heating, lights and the air conditioning clutch, and variations in battery voltage.

When the throttle blade is moved to a more open position, the stepper motor moves the pintle in a direction to increase the cross-sectional area of the bypass channel at a rate determined as a function of throttle movement. On return of the throttle blade to the closed position, the stepper motor moves the pintle back towards the position it held before the throttle blade was opened.

A problem encountered in moving the pintle back to its engine idling position is that this can cause the engine to operate inconsistently for a short period.

The present invention seeks to provide an improved method of and apparatus for controlling the movement of a pintle of an engine and in particular the movement of the pintle back to an engine idling position in a manner which can substantially prevent any instability in engine operation as a result of the movement of the pintle.

According to an aspect of the present invention, there is provided a method of controlling the movement of a pintle of an engine as specified in claim 1.

By controlling the movement of the pintle on the basis of the difference between the actual engine speed and the desired idling speed, it is possible to ensure a smooth transition back to an idling mode.

Advantageously, the method comprises the step of setting the predetermined position as the sum of the position of the pintle at the time the throttle was last moved from an idling position to a more open position plus a predetermined offset determined as a function of vehicle speed; and

enabling closed loop control of the engine idling speed after the pintle has reached the predetermined position. Setting the predetermined position in this manner ensures that the position the pintle moves to during a transition back to the idling mode is not inappropriate for the current vehicle speed.

In an embodiment, closed loop control of the engine idling speed is enabled when the actual engine speed becomes less than the desired engine idling speed. This ensures that the engine speed has substantially stabilised before returning to closed loop control.

According to another aspect of the present invention, there is provided apparatus for controlling the movement of a pintle of an engine as specified in claim 6.

An embodiment of the present invention is described below, by way of illustration only, with reference to the accompanying drawing, in which the sole Figure is a schematic diagram of an idle air control system.

Referring to the Figure, a throttle valve 10 of conventional blade form is located within a choke 12 of an engine manifold and controls the flow of air from the engine manifold to the engine cylinders.

A bypass channel 14 provides a passage in the choke 12 which bypasses the throttle 10 so as to enable air to be inducted into the cylinders when the throttle is closed, thereby enabling the engine to idle. Located within the bypass channel 14 is a valve seat 16 cooperable with a valve or pintle 18 which is movable to vary the cross-sectional area of the passage between the pintle 18 and the valve seat 16, thereby to vary the air flow rate through the bypass passage 14.

The pintle 18 is of conventional form and includes a coil spring 24 for biasing the pintle towards the valve seat 16 and a shaft connected to a control valve 20, which comprises a stepper motor coupled to the shaft for moving the pintle away from the valve seat 16 against the force of the coil spring 24. An input 22 of the control valve 20 is coupled to an engine management system which includes an engine idling speed controller for controlling the control valve 20.

During normal engine idling, the control valve 20 adjusts the position of the pintle 18 to provide a flow of air appropriate to cause the engine to idle at a desired engine speed determined on the basis of the detected engine operating conditions. These detected engine operating conditions include, for example, engine coolant temperature, active engine loads, such as air conditioning clutch and lights, and variations in battery voltage.

When the throttle blade 10 is moved to an open position on depression of the accelerator ped-

al, the pintle 18 is moved away from the valve seat 16 at a rate determined as a function of the movement of the throttle blade 10 so as to increase the air flow through the bypass channel 14.

On return of the throttle blade 10 to its closed position, the pintle 18 is moved back towards the valve seat 16 so as to adjust the air flow through the bypass passage 14 by an amount sufficient to bring the engine speed to the desired engine idling speed, determined on the basis of the above-mentioned engine operating conditions.

The rate at which the pintle 18 is moved back towards the valve seat 16 is determined as a function of the difference between the actual engine speed and the desired engine speed. In this embodiment, the rate of movement of the pintle is determined on the basis of the equation:

$$\text{TIME} = \text{MULT} * (\text{MAX_ERROR} - \text{ERROR}) + \text{DLY},$$

in which, TIME is the delay between consecutive step movements of the stepper motor of the control valve 20; MULT is a calibratable multiplier found by experiment and, in this example, is in the region of 50ms to 500ms; ERROR is the absolute value of the difference between the actual engine speed and the desired engine speed; MAX_ERROR is the maximum value of the difference between the actual engine speed and the desired engine speed considered to occur under such a situation, which can be found by experiment and which in this example is around 800 RPM; and DLY is a predetermined delay calibratable by experiment, and in this example is in the region of 50ms to 500ms.

In the case of a control valve which does not use a stepper motor, the variable TIME in the above equation represents the rate of movement of the pintle, that is the time taken for the pintle to move by a predetermined amount.

It will be apparent to the skilled person that the above-mentioned equation could readily be amended to obtain the rate of movement of the pintle on the basis of the distance to be travelled over a preset time period.

The pintle 18 is moved on the basis of the above equation until it reaches a return position relative to the valve seat 16 corresponding to the initial position of the pintle 18 at the time the throttle blade 10 was first opened plus a calibratable offset determined as a function of the vehicle speed. This calibratable offset is chosen as the point at which normal closed loop control of the engine idling speed can begin, and from which further movement of the pintle under normal closed loop control is not likely to cause any engine operating instabilities.

Once the pintle has reached the return position, the commencement of normal closed loop

control of the engine idling speed by means of the pintle is delayed unless certain conditions have been satisfied. In this embodiment, the condition to be satisfied is that the actual engine speed must drop below the desired engine speed, which in this example is around 800 RPM. While the engine speed is above the desired engine idling speed, closed loop control of the engine idling speed must meet the above-mentioned conditions. On the other hand, when the engine speed is less than the desired engine idling speed, closed loop control of the engine speed is enabled immediately.

On the other hand, normal closed loop control of the engine idling speed is disabled if the following conditions apply:

- (i) the actual engine speed is greater than the desired engine speed and any one of conditions (ii) to (vii) applies;
- (ii) the pintle has been in the return position for less than a predetermined time, in this example 2 seconds;
- (iii) the engine is in a fuel cut-off mode in which fuel to the engine is cut-off during deceleration of the vehicle to improve fuel economy;
- (iv) the manifold absolute pressure, compensated for altitude, is less than a calibratable threshold pressure, in this example 25-30 kPa;
- (v) one of conditions (iii) and (iv) has applied within the previous X seconds, period X being calibratable by experiment and in this example being in the region of 2 seconds;
- (vi) any one of conditions (iii) to (v) applies and a declutch is detected;
- (vii) condition (vi) has applied within the previous Y seconds, period Y being calibratable by experiment and in this example being in the region of 2 seconds.

It will be apparent that if any one of conditions (ii) to (vii) applies, there is the possibility that the engine operating conditions are unstable. In such a case, normal closed loop control of the engine idling speed should remain disabled until engine operation has stabilised.

Of course, one or more of conditions (ii) to (vii) may be omitted or substituted with other tests in other embodiments.

The disclosures in British patent application no. 9220582.2, from which this application claims priority, and in the abstract accompanying this application are incorporated herein by reference.

Claims

1. A method of controlling the movement of a pintle of an engine, which engine comprises a throttle valve (10) for controlling air flow to the engine, a bypass channel (14) bypassing the throttle valve, a movable pintle (18) for control-

ling the flow rate of air through the bypass channel, and control means (20) for controlling the movement of the pintle; the method comprising the steps of determining the position of the throttle valve; determining the position of the pintle; determining a desired engine idling speed on the basis of engine operating conditions; measuring the actual engine speed; when it is determined that the throttle valve has moved from an open position to a substantially closed position, controlling the movement of the pintle to a predetermined position at a rate determined as a function of the difference between the actual engine speed and the desired idling speed.

2. A method according to claim 1, wherein the rate of movement of the pintle is determined on the basis of the equation

$$\text{TIME} = \text{MULT} * (\text{MAX_ERROR} - \text{ERROR}) + \text{DLY},$$

wherein the term TIME is representative of the rate of movement of the pintle, and the terms MULT, MAX_ERROR, ERROR and DLY are as herein defined.

3. A method according to claim 1 or 2, comprising the step of setting the predetermined position as the sum of the position of the pintle at the time the throttle was last moved from an idling position to a more open position plus a predetermined offset determined as a function of vehicle speed; and enabling closed loop control of the engine idling speed after the pintle has reached the predetermined position.

4. A method according to claim 3, wherein closed loop control of the engine idling speed is enabled when the actual engine speed becomes less than the desired engine idling speed.

5. A method according to claim 3 or 4, comprising the step of disabling closed loop control of the engine idling speed if the actual engine speed is greater than the desired engine idling speed and one or more of the following conditions is found to apply:

- a) the pintle has been in the predetermined position for less than a predetermined time;
- b) the engine is in a fuel cut-off mode;
- c) the manifold absolute pressure is less than a threshold pressure;
- d) one of conditions b) and c) has applied within a preceding preset period;
- e) any one of conditions b) to d) applies and it is detected that the vehicle clutch is dis-

engaged; and

f) condition e) has applied within a preceding predetermined period.

6. Apparatus for controlling the movement of a pintle of an engine, which engine comprises a throttle valve (10) for controlling air flow to the engine, a bypass channel (14) bypassing the throttle valve, and a movable pintle (18) for controlling the flow rate of air through the bypass channel; the apparatus comprising processing means adapted to determine the position of the throttle valve and of the pintle, to obtain a desired engine idling speed on the basis of engine operating conditions, and to measure the actual engine speed; and control means (20) for controlling the movement of the pintle; the processing means being adapted to determine a rate of movement of the pintle to a predetermined position as a function of the difference between the actual engine speed and the desired engine idling speed; the control means being adapted, when the throttle valve has moved from an open position to a substantially closed position, to control the movement of the pintle to the predetermined position at the rate determined by the processing means.

7. Apparatus according to claim 6, wherein the processing means is adapted to determine the rate of movement of the pintle on the basis of the equation

$$\text{TIME} = \text{MULT} * (\text{MAX_ERROR} - \text{ERROR}) + \text{DLY},$$

wherein the term TIME is representative of the rate of movement of the pintle, and the terms MULT, MAX_ERROR, ERROR and DLY are as herein defined.

8. Apparatus according to claim 6 or 7, wherein the processing means is adapted to set the predetermined position as the sum of the position of the pintle at the time the throttle was last moved from an idling position to a more open position plus a predetermined offset determined as a function of vehicle speed; and to enable closed loop control of the engine idling speed after the pintle has reached the predetermined position.

9. Apparatus according to claim 8, wherein the processing means is adapted to enable closed loop control of the engine idling speed when the actual engine speed becomes less than the desired engine idling speed.

10. Apparatus according to claim 8 or 9, wherein the processing means is adapted to disable closed loop control of the engine idling speed if the actual engine speed is greater than the desired engine idling speed and one or more of the following conditions is found to apply:
- a) the pintle has been in the predetermined position for less than a predetermined time;
 - b) the engine is in a fuel cut-off mode;
 - c) the manifold absolute pressure is less than a threshold pressure;
 - d) one of conditions b) and c) has applied within a preceding preset period;
 - e) any one of conditions b) to d) applies and it is detected that the vehicle clutch is disengaged; and
 - f) condition e) has applied within a preceding predetermined period.

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