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(11) **EP 1 072 778 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
31.01.2001 Bulletin 2001/05

(51) Int. Cl.⁷: **F02D 41/14**, F02D 41/16

(21) Application number: **00830518.7**

(22) Date of filing: **20.07.2000**

(84) Designated Contracting States:
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE**
Designated Extension States:
AL LT LV MK RO SI

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(30) Priority: **28.07.1999 IT TO990663**

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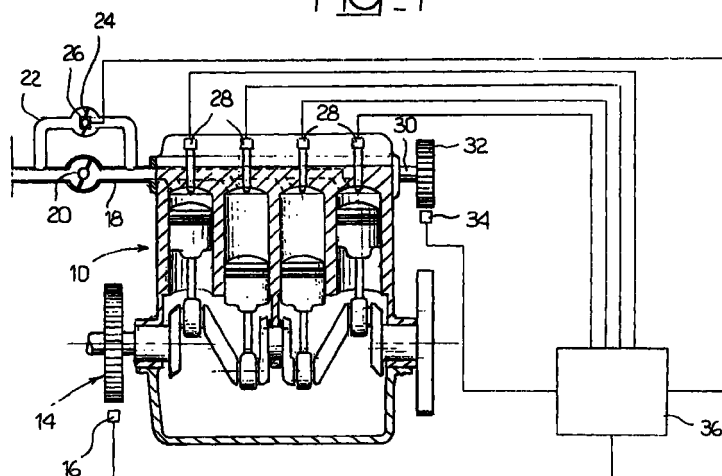
(54) **Method for controlling idling in an internal combustion engine**

(57) Method for controlling idling in an internal combustion engine for vehicles, comprising the phases of:

- supervising at least one operating parameter of the engine, and
- correcting the quantity of air/fuel delivered to the engine as a function of the variations of the said operating parameter, in order to maintain the revolution speed of the engine essentially equivalent to

a pre-established value of reference. The objective of the method is to establish an estimated value of a torque applied to the engine as a function of an angular acceleration value detected during a cycle of the internal combustion engine and to effect a correction of the quantity of air/fuel delivered to the engine as a function of the variations in the said estimated torque value.

Fig. 1



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Description

[0001] The present invention concerns a method for controlling idling in an internal combustion engine for vehicles.

[0002] Modern motor vehicles are provided with a variety of accessory devices, such as for example the compressor of the air conditioning system, the alternator and relevant electric loads, which together generate a resisting torque applied to the output shaft of the engine. This resisting torque has a value that varies as a function of the operating condition of each individual accessory device. During idling of the internal combustion engine variation of the resisting torque caused by the accessory devices tends to produce a variation in the number of revolutions of the engine.

[0003] Modern engines for vehicles are normally provided with an electronic control unit which is capable of correcting the quantity of air and fuel fed to the engine to keep the revolution speed of the engine as constant as possible during idling. In traditional solutions the electronic control unit detects the engine revolution speed and corrects the variations according to a pre-established revolution speed, varying the quantity of air and fuel injected or varying the spark advance of the engine. Control systems of the tradition type have no information on the resisting load applied to the motor and make corrections as a function of the variation in speed of the motor caused by the variation in resisting torque. In practice, the correction is made after having detected the outcome of a variation in resisting torque. As the engine has a certain degree of inertia, there is a delay from the moment in which the resisting torque varies to the moment in which the electronic control unit detects a variation in engine speed. To prevent the engine from cutting out during the time required by the electronic control unit of the engine to make the correction, the pre-established revolution speed of the engine must be relatively high, so that the inertia of the engine compensates the response times of the idling control system.

[0004] The problem on which the present invention is based is to reduce the idling revolution speed of an internal combustion engine while preventing the engine from cutting out due to sudden increases in the resisting torque produced by accessory devices.

[0005] According to the present invention, this objective is reached by a method the characteristics of which are the subject-matter of the claims.

[0006] The present invention shall now be described in detail with reference to the enclosed drawings, given merely as an unlimited example, in which:

figure 1 is a schematic view of an internal combustion engine with electronic idling control, and
figure 2 is a diagram illustrating the variation in pressure in the combustion chamber of a cylinder and the variation in torque applied to the engine

shaft during a cycle of 360° of the engine.

[0007] In figure 1 a four cylinder four-stroke internal combustion engine is indicated with 10, provided with an engine shaft 12, mounted on which is a tone wheel 14 associated to a sensor 16, for example of the electromagnetic type, the task of which is to detect the instant revolution speed of the engine shaft 12. The engine 10 is provided with an intake manifold 18 fitted with a throttle valve 20 controlled by the user by means of the accelerator pedal. A by-pass manifold 22 is fitted parallel to the throttle valve 20. A second throttle valve 24 is fitted on the by-pass manifold 22 and is operated by an electric actuator 26. A plurality of injectors 28 are fitted on the intake manifold 18 in relation to the various cylinders of the engine 10. A distributor shaft 30 controls opening and closing of intake and exhaust valves (not illustrated). Mounted on the distributor shaft 30 is a tone stroke wheel associated to a sensor 34 that provides a signal indicating the stroke of the engine 10. An electronic control unit 36 receives the signals from the angular velocity sensor 16 and the stroke sensor 34. The electronic control unit 36 is programmed, among other things, to control idling of the engine 10. On the basis of the information provided by the sensors 16 and 34 the control unit 36 corrects the air flow aspirated by the motor 10 in conditions of idling by opening or closing the throttle valve 24 by means of the actuator 26. Simultaneously to the correction of the air flow aspirated, the control unit 36 corrects the quantity of fuel injected modifying the opening time of the injectors 28.

[0008] The mechanical balance of a thermal engine viewed as a rigid body can be expressed in mean values on the cycle as follows:

$$C_{ine} = C_{ind} - C_{res} - C_{car}$$

that is, the torque of inertia C_{ine} is equal to the difference of the torque developed by the gases C_{ind} and the internal resisting torques C_{res} and load torque C_{car} applied to the engine shaft. The torque of inertia C_{ine} can be divided into two components: $C_{ine} = C_{rot} + C_{alt}$, in which C_{rot} is the torque of inertia of the rotating masses and C_{alt} is the torque due to the masses in alternate movement. The torque C_{alt} is proportional to the square of engine revolution speed and is negligible at idling speed of the engine. Therefore, it can be approximately assumed that $C_{alt} = 0$ to obtain:

$$C_{rot} = C_{ind} - C_{res} - C_{car}$$

[0009] In real time handling of data by the electronic control unit of an engine the calculation power required must be reduced to a minimum without losing the content of information required for the control. According to the present invention, the electronic control unit 36 is programmed to acquire, in idling, information relevant to the total resisting torque given by the sum of the compo-

nents $C_{rot} + C_{res} + C_{car}$.

[0010] The load torque C_{car} may be distinguished in two components:

C_{af} : external load to the engine viewed on its own, that is, disengaged from the drive (for example, hydraulic steering, air conditioning, electric loads);
 C_{at} : load applied downstream of the flywheel (car mass in the various gears and load conditions) through the elastic curve of the drive.

[0011] With the vehicle stopped (gear disengaged) the components C_{at} is null and torque due to the load applied to the engine shaft C_{car} is equivalent to the external load to the engine due to accessory devices controlled directly or indirectly by the engine.

[0012] The method with which the electronic control unit 36 acquires information relevant to the resisting torque applied to the engine shaft shall be explained subsequently with reference to the diagram in figure 2. The graph indicated with P gives a schematic indication of the variation in pressure inside the combustion chamber during the cycle corresponding to a revolution of 360° of the engine shaft. The maximum of the pressure curve P occurs shortly after the top dead centre indicated in the figure with PMS (TDC). Figure 2 also indicates the variation in torque applied by gases in expansion to the engine shaft. The torque has a negative value in the crank angle interval between 0 (PMS) and -180° and a positive value in the interval of between 0 (PMS) and $+180^\circ$. The minimum value of the resisting torque C_{min} from the physical point of view represents the value of the total resisting torque: $C_{min} = C_{res} + C_{af}$ (in conditions of the gear disengaged). The mean value during the cycle of 360° of the torque C from the physical point of view represents the torque of inertia of the rotating masses C_{rot} .

[0013] The instant torque C is proportional to instant acceleration of the crankshaft of the engine. Consequently, according to the present invention, the electronic control unit 36 is programmed to acquire by means of the sensor 16 and the tone wheel 14 acceleration data that represent the torque $C_{min} = C_{res} + C_{af}$ and the torque C_{rot} . An instant acceleration value can be calculated with an expression of the type:

$$A_i = \frac{\Delta\omega}{\Delta t}$$

where A_i is the instant acceleration in a point of the cycle and $\Delta\omega$ is the variation of velocity measured in the interval of time Δt relevant to the point of the cycle considered.

[0014] The minimum value of the torque may be estimated as the mean value of acceleration in the interval $\Delta\alpha$ (figure 2), the position of which is established as a function of the angular position of the tone wheel.

[0015] To sum up, during each cycle of 360° of the engine the electronic control unit 36 acquires by means

of the velocity sensor 14, 16 information on the estimated resisting torque, given by the sum of two acceleration components: a first which is calculated as the mean value of acceleration of the engine shaft calculated on 360° of crank angle and a second acceleration calculated as the minimum instant value in a pre-established interval $\Delta\alpha$ immediately before the top dead centre. In reality the two accelerations are not coherent as scale factors as the former is calculated as the instant value $C_{res} + C_{af}$ while C_{rot} is calculated as the mean value. The two components are therefore weighed appropriately by means of calibration parameters. These parameters also compensate delays in control and mechanical and hydrodynamic inertia of the system.

[0016] On the basis of data representing the torque value $C_{rot} + C_{res} + C_{af}$, the electronic control unit 36 makes corrections in the air flow and the amount of fuel injected according to a mapping established experimentally for the purpose of maintaining the engine revolution speed constant. The control system based on detecting the torque value overrides a control system of the tradition type based on detecting the engine revolution speed. The additional control system more rapidly compensates situations in which variations in load occur as it directly supervises the physical size which is the cause of variations in angular velocity.

[0017] Naturally, with no variation to the principle of the invention, the constructional details and forms of execution may be varied widely in relation to the invention described and illustrated herein, without however departing from the scope of the present invention, as defined in the claims that follow.

Claims

1. Method for controlling idling in an internal combustion engine for vehicles, comprising the phases of:

- supervising at least one operating parameter of the engine, and
- correcting the quantity of air/fuel delivered to the engine as a function of the variations of the said operating parameter, in order to maintain the revolution speed of the engine essentially equivalent to a pre-established value of reference;

the method is characterised in that it establishes an estimated value of a torque applied to the engine as a function of an angular acceleration value detected during a cycle of the internal combustion engine and to effect a correction of the quantity of air/fuel delivered to the engine as a function of the variations in the said estimated torque value.

2. Method according to claim 1, characterised in that the estimated torque applied to the engine shaft is established as a function of the first angular acceleration value measured in an interval ($\Delta\alpha$) immediately before the top dead centre position of the engine and a second acceleration value calculated as the mean value during a cycle of the engine. 5
3. Method according to claim 2, characterised in that the aforesaid first acceleration value is an indicative value of the minimum acceleration value during a cycle of the engine. 10

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Fig. 1

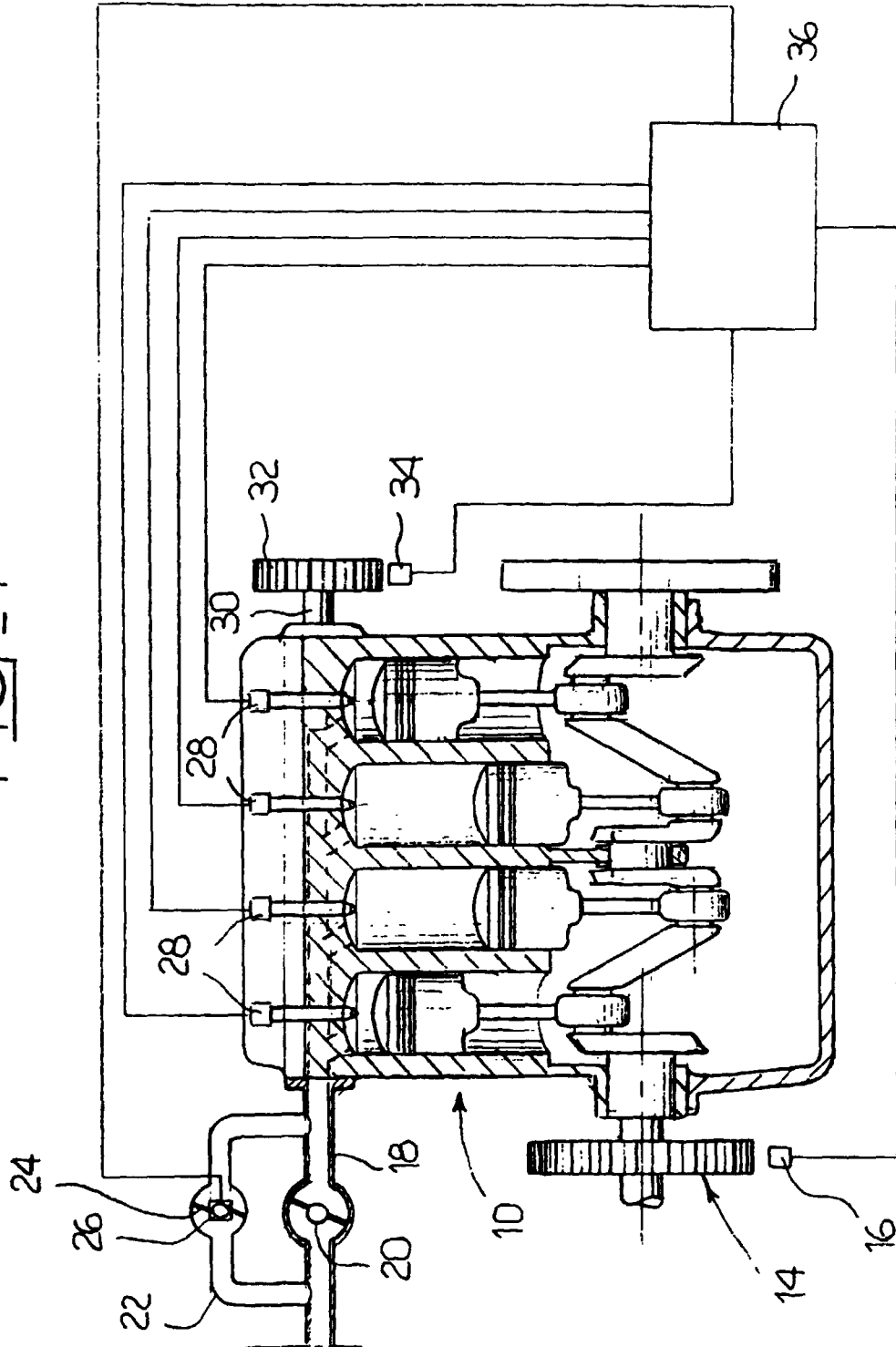


Fig. 2

