Fuel control apparatus for a fuel injection system of an internal combustion engine.

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Description

Background of the Invention

This invention relates to a fuel control apparatus for a fuel injection system of an internal combustion engine which measures the rate of air intake into the engine using an air flow sensor and controls the supply of fuel to the engine based on the output of the sensor.

In an internal combustion engine which employs a fuel injection system, it is conventional to dispose an air flow sensor (hereinunder abbreviated as AFS) upstream of the throttle valve of the engine and to calculate the rate of air intake per each engine revolution based on the output of the AFS. The injection of fuel is then controlled based on the calculated intake air flow rate.

Since the AFS is disposed upstream of the throttle valve, the air flow rate measured by the AFS does not always coincide with the actual air flow rate into the engine cylinders. In particular, when the throttle valve is abruptly opened, there is a sudden increase in the air flow in the AFS, but due to the provision of a surge tank between the throttle valve and the engine cylinders, the increase in the air flow rate into the cylinders is more gradual and of a smaller magnitude than that into the AFS. Accordingly, the air flow measured by the AFS is greater than the actual air flow into the engine, and if the fuel supply were controlled based solely on the value measured by the AFS during a single brief period when the air flow rate was in transition, the fuel-air mixture would be overly rich. Therefore, the actual air flow rate into the engine cylinders is calculated as a weighted average of the value measured by the AFS over several periods, such as during two consecutive half-revolutions of the engine, and more accurate fuel control can be performed.

However, when the AFS is of the Karman vortex type, it produces output pulses whose frequency varies with the intake air flow rate, which depends upon the load of the engine. The frequency of the output typically varies from 40 to 1200 Hz. Furthermore, the frequency of the AFS output greatly fluctuates under a heavy load. At such a high frequency, a computer for processing the output signals from the AFS cannot keep up with the output signals, the amount of intake air per engine revolution cannot be accurately detected, and the fuel supply cannot be correctly controlled.

French patent specification 2 429 896 describes a fuel injection system which comprises an air flow sensor for generating a pulse signal at a frequency proportional to the air flow through the intake passage of the internal combustion engine. If the frequency of the pulse signal is greater than a predetermined amount, the system is operative for frequency dividing the signal. No frequency division takes place if the frequency of the power signal is less than the predetermined amount. A controller is provided for calculating and control-

ling the fuel injection amount on the basis of the undivided frequency of the pulse signal and on the basis of other criteria such as throttle position, water temperature and RPM. The frequency divided signal is used to actuate the fuel injection valves.

Japanese patent specification JP 57 193731 relates to a fuel control for an internal combustion engine in which the division ratio of a frequency divider is changed in dependence upon the output frequency of an air flow sensor.

Summary of the Invention

It is therefore an object of the present invention to provide a fuel control apparatus for an internal combustion engine which can accurately control the supply of fuel to the engine over the entire operating range of the engine.

According to the present invention, there is provided a fuel control apparatus for a fuel injection system of an internal combustion engine, said fuel injection system having at least one fuel injector for supplying fuel to said engine, comprising:

- air flow sensing means for sensing the air flow rate into the air intake pipe of said engine and producing an electrical output having a frequency which is proportional to said air flow rate;
- crank angle sensing means for producing an electrical output pulse each time the crankshaft of said engine is at a prescribed crank angle;
- frequency division means for performing frequency division of the output signal of said air flow sensor when the engine load exceeds a prescribed value and for producing an output having the same frequency as the output of said air flow sensing means when the engine load is below said prescribed value; and
- controls means for calculating the air flow rate into the cylinders of said engine based on the output of said frequency division means and said crank angle sensing means and for controlling said fuel injector in dependence upon said calculated air flow rate, the temperature of the engine and whether the engine is idling.

In an embodiment of the present invention, the intake air flow rate into the air intake pipe of the engine is measured by a Karman vortex air flow sensor, and the actual air intake flow rate into the cylinders of the engine is calculated by the controller based on the output of the air flow sensor and the crank angle sensor, which produces an electrical output at prescribed crank angles of the engine crankshaft. The supply of fuel to the engine is controlled based on the calculated intake air flow rate. When the load on the engine exceeds a certain level, the frequency divider performs frequency division of the output of the air flow sensor. The controller then performs calculations based on the frequency-divided output, and there is ample time for the controller to calculate the intake air flow rate. When the load on the engine is below this level, the frequency divider produces an output signal having the same frequency as the output signal of the air flow sensor.
flow sensor, and the controller performs calculations based thereon. The magnitude of the engine load is determined based on the number of output pulses of the air flow sensor between consecutive pulses of the crank angle sensor.

Brief Description of the Drawings

Figure 1 is a block diagram of an embodiment of a fuel control apparatus in accordance with the present invention.

Figure 2 is a block diagram showing the construction of the embodiment of Figure 2 in greater detail.

Figure 3 is a block diagram of a model of the air intake system of an internal combustion engine employing the present invention.

Figure 4 is a diagram of the relationship between the air intake into the AFS of Figure 3 and the air intake into the cylinders of the engine.

Figure 5 is a waveform diagram showing the changes in the rate of air intake into the intake system of Figure 3 when the throttle valve is suddenly opened.

Figure 6 is a flow chart of the main program executed by the CPU 40 of Figure 2.

Figure 7 is a diagram showing the relationship between the output frequency \( F_o \) of the AFS of the embodiment of Figure 2 and a fundamental ignition timing conversion coefficient \( f_1 \).

Figure 8 and Figure 9 are flow charts of interrupt handling routines performed by the CPU 40 of Figure 2.

Figure 10 is a timing diagram showing the values of various parameters during the operation of the embodiment of Figure 2.

In the drawings, the same reference numerals indicate the same or corresponding parts.

Description of the Preferred Embodiments

Hereinbelow, a preferred embodiment of a fuel control apparatus in accordance with the present invention will be described while referring to the accompanying drawings. Figure 1 is a block diagram showing the overall structure of this embodiment as applied to a four-cylinder internal combustion engine 1. The engine 1 has an air intake pipe 15, at the upstream end of which is installed a Karman vortex AFS 13. The AFS 13 produces electrical pulses having a frequency corresponding to the intake air flow rate through the AFS 13. An air cleaner 10 disposed upstream of the AFS 13. The air intake pipe 15 is equipped with a surge tank 11, a throttle valve 12, and four fuel injectors 14, each of which supplies fuel to one of the four cylinders of the engine 1. Combustion gas is exhausted from the engine 1 through an exhaust pipe 16. The engine 1 is further equipped with a crank angle sensor 17 which senses the angle of rotation of the crankshaft of the engine 1 and produces an electrical output pulse at prescribed crank angles, such as one pulse for every 180 degrees of crankshaft rotation. The water temperature of the engine cooling water is measured by a water temperature sensor 18, comprising a thermistor or the like, which produces an electrical output signal corresponding to the temperature, and the idling of the engine 1 is detected by an idling switch 19 which produces a corresponding electrical output signal.

A fuel control apparatus comprises the AFS 13, a load detector 20 for detecting the number of output pulses of the AFS 13 between consecutive pulses of the crank angle sensor 17, a calculating mechanism 21 for calculating the actual amount of intake air which enters the cylinders of the engine between consecutive pulses of the crank angle sensor 17 based on the output of the load detector 20, and a controller 22 which controls the fuel injectors 14 based on the output from the calculating mechanism 21, the water temperature sensor 18, and the idling switch 19.

Figure 2 shows the structure of this embodiment more concretely. The load detector 20, the calculating mechanism 21, and the controller 22 together constitute a control unit 30 which controls the four injectors 14 and into which the output signals of the AFS 13, the crank angle sensor 17, the water temperature sensor 18, and the idling switch 19 are input. The control unit 30 is controlled by a CPU 40 having a ROM 41 and a RAM 42. The output signal of the AFS 13 is input to a frequency divider 31 which produces an output signal having one-half the frequency of the AFS output signal. The output signal of the frequency divider 31 is input to one of the input terminals of an exclusive OR gate 32. The other input terminal is connected to an output port P1 of the CPU, whose output corresponds to the status of a frequency division flag in the RAM 42. The output terminal of the exclusive OR gate 32 is connected to a counter 33 and an interrupt input port P3 of the CPU 40. The output signal of the temperature sensor 18, which is an analog value, is input to an A/D converter 35 through an interface 34a, and the digitalized value is input to the CPU 40. The output signal from the idling switch 19 is input to the CPU 40 through another interface 34b. The output signal from the crank angle sensor 17 is input to a waveform shaper 36, and the shape waveform is input to an interrupt input port P4 of the CPU 40 and to a counter 37. A timer 43 is connected to an interrupt input port P5 of the CPU 40. An unillustrated battery for the engine is connected to an A/D converter 39, which produces a digital output signal corresponding to the voltage \( V_b \) of the battery and outputs the signal to the CPU 40. A timer 43 is connected between an output port P2 and the CPU 40 and a driver 44 which is connected to each of the four fuel injectors 14.

Before describing the operation of this embodiment in detail, the principles underlying the calculations which are performed by the CPU 40 will be explained while referring to Figures 3 through 5. Figure 3 illustrates a model of the air intake system of the internal combustion engine 1 of Figure 1. The displacement of the engine 1 is \( V_c \), while the volume from the throttle valve 12 to the intake valves of the engine 1 is \( V_v \).
Figure 4 illustrates the relationship between the air flow rate $Q_a$ into the AFS 13 and the air flow rate $Q_a$ into the cylinders of the engine 1. In Figure 4, (a) illustrates the output (abbreviated as SGT) of the crank angle sensor 17 which outputs a pulse every 180 degrees of crankshaft rotation, while (d) illustrates the output of the AFS 13. The length of the time between the (n-2)th rise and the n-1)th rise of SGT is $t_n - 1$, and the time between the (n-1)th rise and the nth rise is $t_n$. The amounts of intake air which pass through the AFS 13 during periods $t_n - 1$ and $t_n$ are $Q_{a(n-1)}$ and $Q_{a(n)}$, respectively, and the amounts of air which enter the cylinders of the engine 1 during the same periods $t_n - 1$ and $t_n$ are $Q_{ae(n-1)}$ and $Q_{ae(n)}$, respectively. Furthermore, the average pressure and the average intake air temperature in the surge tank 11 during periods $t_n - 1$ and $t_n$ are respectively $P_{a(n-1)}$ and $P_{a(n)}$ and $T_{a(n-1)}$ and $T_{a(n)}$. $Q_{ae(n-1)}$ corresponds to the number of the output pulses from the AFS 13 in the time period $t_n - 1$. As the rate of change of the intake air temperature is small, $T_{a(n-1)}$ is approximately equal to $T_{a(n)}$, and if the charging efficiency of the internal combustion engine 1 is constant, then the following relationships hold:

$$P_{a(n-1)} 	imes V_e = Q_{ae(n-1)} 	imes R 	imes T_{a(n)}$$  
$$P_{a(n)} 	imes V_e = Q_{ae(n)} 	imes R 	imes T_{a(n)}$$

wherein $R$ is a constant. If the amount of air which remains in the surge tank 11 and the air intake pipe 15 during period $t_n$ is $\Delta Q_{ae(n)}$, then

$$\Delta Q_{ae(n)} = Q_{ae(n)} - Q_{ae(n-1)} = V_e \times \frac{1}{R T_e} \times \left( P_{a(n)} - P_{a(n-1)} \right)$$

and from Equations (1) – (3), the following equation is obtained:

$$Q_{ae(n)} = \left[ \frac{1}{\left( 1 + V_e/V_{el} \right) \times Q_{ae(n-1)} + \left( 1 - (1 + V_e/V_{el}) \times Q_{ae(n)} \right)} \right]$$

Accordingly, the amount of air $Q_{ae(n)}$ which enters the internal combustion engine 1 in period $t_n$ can be calculated based on the amount of air $Q_{ae(n)}$ which passes through the AFS 13. For example, if $V_e = 0.5$ liters and $V_e = 2.5$ liters, then

$$Q_{ae(n)} = 0.83 \times Q_{ae(n-1)} + 0.17 \times Q_{ae(n)}$$

Figure 5 illustrates the state within the air intake passageway 15 when the throttle valve 12 is suddenly opened. In Figure 5, (a) shows the degree of opening of the throttle valve 12, and (b) shows the air flow rate $Q_a$ through the AFS 13. As can be seen from (b), the air flow rate $Q_a$ abruptly increases and overshoots a steady-state value, after which it decreases to the steady-state value. (c) shows how the air flow rate $Q_a$ into the cylinders of the engine increases gradually to the same steady-state value without overshooting, and (d) shows the variation in the pressure $P$ within the surge tank 11.

Next, the operation of the embodiment illustrated in Figure 2 will be explained. The output of the AFS 13 is frequency divided by the frequency divider 31, and the output thereof, which has a frequency which is half of that of the AFS output, is input to counter 33 through the exclusive OR gate 32, which is controlled by the CPU 40. Counter 33 measures the period between the falling edges of the output of the exclusive OR gate 32. Each time there is a fall in the output of the exclusive OR gate 32, which is input to interrupt input port P3, the CPU 40 performs interrupt handling and the period of counter 33 is measured. The interrupt handling is performed once every one or two periods of the output of the AFS 13, depending on the status of output port P1 of the CPU 40, which depends on the status of the frequency division flag within the RAM 42. The output of the water temperature sensor 18 is converted into a voltage by interface 34a, the output of the interface 34a is changed into a digital value by A/D converter 35 at prescribed intervals, and the output of A/D converter 35 is input to the CPU 40. The output of the crank angle sensor 17 is input to interrupt input port P4 of the CPU 40 and to counter 37 through the waveform shaper 36. The output of the idling switch 19 is input to the CPU 40 through interface 34b. The CPU 40 performs interrupt handling on each rising edge of the output of the crank angle sensor 17, and the period between the rising edges of the output of the crank angle sensor 17 is determined based on the output of counter 37. At prescribed intervals, timer 38 generates an interrupt request which is applied to interrupt input port P5 of the CPU 40. A/D converter 39 performs A/D conversion of the voltage $V_e$ of the unillustrated battery, and at prescribed intervals, the CPU 40 reads in this battery voltage data. Timer 43 is preset by the CPU 40 and is triggered by output port P2 of the CPU 40. The timer 43 outputs pulses of a prescribed width, and this output drives the injectors 14 through the driver 44.

Next, the operation of the CPU 40 will be explained while referring to the flow charts of Figures 6, 8, and 9. Figure 6 illustrates the main program of the CPU 40. When a reset signal is input to the CPU 40, the RAM 42, the input ports, and the like are initialized in Step 100. In Step 101, A/D conversion of the output of the water sensor 18 is performed and the result is stored in the RAM 42 as $W$. In Step 102, A/D conversion of the battery voltage is performed and the result is stored in the RAM 42 as $V$. In Step 103, the rotational speed $N_e$ in RPM of the engine is determined by calculating the value of $30/T_e$, wherein $T_e$ is the period in seconds of the output signal from the crank angle sensor 17 and equals the time for the crankshaft to turn 180 degrees. In Step 104, the frequency $F_e$ of the output signal of the AFS 13 is calculated by the equation $AN = N_e/30$. AN is referred to as load data; it is equal to the number of output pulses which are generated by the AFS 13 between the rising edges of two consecutive pulses of the crank angle sensor 17 and is indicative of the engine load. In Step 105,
based on the output frequency $F_o$, a fundamental ignition timing conversion coefficient $K_i$ is calculated using a function $f_i$ which has a value with respect to $F_o$ as shown in Figure 7. In Step 106, the fundamental ignition timing conversion coefficient $K_i$ is corrected by a function $f_i$ which depends on the value of the water temperature data $W_T$, and the corrected value is stored in the RAM 42 as ignition timing conversion coefficient $K_i$. In Step 107, based on the battery voltage data $V_b$, a data table $f_b$, which is previously stored in the ROM 41 is read, and the dead time $T_D$ (the time lag in the response of the fuel injectors 14) is calculated and stored in the RAM 42. After Step 107, the program recycles by returning to Step 101.

Figure 8 illustrates an interrupt handling routine which is performed by the CPU 40 each time the output of the exclusive OR gate 32 fails. In Step 201, the output $T_F$ of the counter 33 is read, and then the counter 33 is cleared. $T_F$ is the period between consecutive rises in the output of the exclusive OR gate 32. In Step 202, if the frequency division flag of the RAM 42 is set, then in Step 204, two times a value which is referred to as the remaining pulse data $P_R$ is added to the cumulative pulse data $P_R$ to obtain a new value for the cumulative data $P_R$. The cumulative pulse data $P_R$ is the total number of pulses which are output by the AFS 13 between the rises in consecutive pulses in the output of the crank angle sensor 17. In order to ensure the accuracy in calculation of the CPU 40, $P_R$ is incremented by 156 for each pulse from the AFS 13, so that the value of $P_R$ equal 156 times the actual number of output pulses of the AFS 13. In Step 202, if the frequency division flag is reset, then in Step 206, the remaining pulse data $P_R$ is added to the cumulative pulse data $P_R$. In step 207, the remaining pulse data $P_R$ is set equal to 156. In Step 208, it is determined whether or not the load data $A_N$ is greater than a prescribed value $Y$. If it is greater, the program proceeds to Step 210, and if it is smaller, the program proceeds to Step 209. In Step 209, the period $T_D$ is compared with a prescribed value $X$, which is 2 msec, when the frequency division flag is reset and is 4 msec, when the frequency division flag is set. If $T_D \geq X$ msec, then the program proceeds to Step 211. Otherwise it proceeds to Step 210, in which the frequency division flag is set. After Step 210, it is determined, in Step 210, whether the previous frequency division flag is set, and if the previous frequency division flag is cleared, in Step 213 the period $T_F$ of the output pulse of the AFS 13 multiplied by 2 is stored in the RAM 42 as $T_A$. On the other hand, if it is determined that the previous frequency division flag is set, then in Step 214, the period $T_F$ is simply stored in the RAM as $T_A$. After the processing of Step 213 or 214, interrupt handling is completed.

On the other hand, in Step 209, if it is determined that $T_D \geq X$ msec, the frequency division flag is cleared in Step 211, and then in Step 215, it is determined whether or not previous frequency division flag is cleared. If not, in Step 216 the above-mentioned period $T_F$ divided by 2 is stored in the RAM 42 as $T_A$, but if so, in Step 217 the period $T_F$ is simply stored in the RAM 42 as $T_A$. Thereafter, in Step 218, the level of the output port $P_1$ is inverted and interrupt handling is completed. Thus, in short, if Step 210 is performed, an interrupt request is input to the interrupt input port $P_3$ on every output pulse of the AFS 13. In contrast, if Step 211 is performed, an interrupt request is input to the interrupt input port $P_3$ upon each output pulse of the AFS 13.

Figure 9 illustrates an interrupt handling routine which is performed by the CPU 40 each time an interrupt request is input to the interrupt input port $P_4$, which takes place upon each rise in the output of the crank angle sensor 17. This flow chart will be explained for the case that an interrupt request is input at time $t_1$, in Figure 10, which is a timing diagram illustrating (a) the output of the frequency divider 31; (b) the output of the crank angle sensor 17; (c) the calculated value of $P_D$; and (d) the calculated value of $P_R$ during the processing shown in Figure 9 when the frequency division flag is cleared. In Step 301, the period between the present rise (at time $t_{152}$) and the previous rise (at time $t_{13}$) in the output of the crank angle sensor 17 is read from the counter 37 and is stored in the RAM 42 as period $T_F$. The counter 37 is then cleared. In Step 302, it is determined whether there was an output pulse from the gate 32 during the period $T_F$. If so, then in Step 303, the time difference $T_D$ between the time of the immediately preceding output pulse of the gate 32 (at time $t_{13}$) and the time of the present interrupt request (at time $t_{15}$) is calculated. In the case of Figure 10, $T_F = t_{152} - t_{13}$. When there was no output pulse from the gate 32 during period $T_F$, then period $T_F$ is set equal to period $T_A$. In Step 305, the time difference $T_D$ is converted into output pulse data $\Delta P$. The pulse data $\Delta P$ is the amount by which the cumulative pulse data $P_R$ should be increased for the length of time $T_F$. In this case, $\Delta P$ is set equal to $156 \times T_F/T_A$. In this connection, as can be seen from Figure 10, the exact value of $\Delta P$ is $156 \times T_F/\left(t_{152} - t_{13}\right)$. However, as $t_{13}$ has yet to take place it is assumed that $t_{152} - t_{13}$ is equal to $T_A$, or in other words, it is assumed that the output of the gate 32 will remain substantially constant over two cycles. In Step 306, if the value of pulse data $\Delta P$ is less than or equal to 156, then the program proceeds to Step 308, and if it is larger, then in Step 307 $\Delta P$ is reduced to 156. In Step 308, the remaining pulse data $P_R$ is decreased by the pulse data $\Delta P$, and the decreased value is made the new remaining pulse data $P_R$. In Step 309, if the remaining pulse data $P_R$ is positive or zero, then the program proceeds to Step 313a, and otherwise, the calculated value of the pulse data $\Delta P$ is too much greater than the output pulse of the AFS 13, so in Step 310, the pulse data $\Delta P$ is set equal to $P_R$, and in Step 312, the remaining pulse data $P_R$ is set equal to zero. In step 313a, it is determined whether the frequency division flag is set. When it is reset, then the Step 313b the cumulative pulse
data $P_R$ is increased by the pulse data $\Delta P$, and when it is set, then in Step 313c $P_a$ is increased by $2 \times \Delta P$, and a new value for the cumulative pulse data $P_a$ is obtained. $F_R$ is proportional to the number of pulses which it is thought that the AFS 13 output between consecutive rises in the output of the crank angle sensor 17, i.e., between times $t_1$ and $t_2$. In Steps 314a-c, a calculation corresponding to Equation (5) is performed and a new value of the load data AN is calculated based on the old value of the load data AN which was calculated up to the previous rise in the output of the crank angle sensor 17 (at time $t_1$) and the cumulative pulse data $P_a$ which was just calculated. In step 314a, it is first determined whether the idling switch is on, indicating an idling state. If it is on, then in Step 314c, the calculation $AN = (K_3)AN + (1-K_3)P_a$ is performed, and if idling switch 23 is off, then in Step 315c, the calculation $AN = (1-K_4)AN + (K_4)P_a$ is performed, wherein $K_3$ and $K_4$ are constants ($K_3 > K_4$). In Step 315, if the new load data AN is larger than a prescribed value $Z$, then in Step 316 it is reduced to $Z$ so that even when the throttle of the engine 1 is fully open the load data AN will not overly exceed the actual value. In Step 317, the cumulative pulse data $P_a$ is set equal to zero. In Step 318, ignition timing data $T_i$ is calculated based on the load data AN, the ignition timing conversion coefficient $K_0$, and the dead time $T_D$ in the manner $T_i = AN \times K_0 + T_D$. In Step 319, the ignition timing data $T_i$ is set in the timer 43, and by triggering the timer 43 in Step 320, the four injectors 14 are simultaneously driven in accordance with the value of $T_i$, and interrupt handling is completed.

In the manner described above, in accordance with the present invention, when the load on the engine (as indicated by the value of the load data AN) is below a certain level, a signal having the same frequency as the output of the AFS 13 is input to the CPU 40, and when the load (and the value of AN) exceeds this level, the output of the AFS 13 is frequency divided before being input to the CPU 40. Therefore, ample time for the CPU 40 to calculate the rate of air intake into the engine is guaranteed, and the fuel supply can be accurately controlled over the entire operating range of the engine.

In the above-described embodiment, the output pulses of the AFS 13 are counted between the rises in the output of the crank angle sensor 17, but counting may be performed between falls. Furthermore, the number of output pulses of the AFS 13 can be counted over several periods of the output of the crank angle sensor 17 instead of over a single period. Also, although the actual number of output pulses of the AFS 13 were counted, a value which is the number of output pulses of the AFS 13 multiplied by a constant corresponding to the output frequency of the AFS 13 may be counted. In addition, the angle of the crankshaft need not be detected by a crank angle sensor 17, and the same effects can be obtained using the ignition signal for the engine.

**Claims**

1. A fuel control apparatus for a fuel injection system of an internal combustion engine (1), said fuel injection system having at least one fuel injector (14) for supplying fuel to said engine, comprising:

- air flow sensing means (13) for sensing the air flow rate into the air intake pipe (15) of said engine and producing an electrical output having a frequency which is proportional to said air flow rate;
- crank angle sensing means (17) for producing an electrical output pulse each time the crankshaft of said engine is at a prescribed crank angle;
- frequency division means (31) for performing frequency division of the output signal of said air flow sensor when the engine load exceeds a prescribed value and for producing an output having the same frequency as the output of said air flow sensing means when the engine load is below said prescribed value;
- and control means (22) for calculating the air flow rate into the cylinders of said engine based on the output of said frequency division means and said crank angle sensing means and for controlling said fuel injector in dependence upon said calculated air flow rate, the temperature of the engine and whether the engine is idling.

2. A fuel control apparatus as claimed in claim 1, wherein said control means (22) includes means for controlling said frequency division means so as to perform frequency division when the number of output pulses of said air flow sensor between consecutive output pulses of said crank angle sensor exceeds a prescribed value, or when the period of the output pulses of said air flow sensor is below a prescribed value.

**Patentansprüche**

1. Vorrichtung zur Regelung eines Kraftstoffeinspritzsystems eines Verbrennungsmotors (1), wobei das Kraftstoffeinspritzsystem mindestens eine Kraftstoffeinspritzte (14) aufweist, um dem Motor Kraftstoff zuzuführen, umfassend

- eine Luftströmungsmesseinrichtung (13) zur Messung des Luftströmungsdurchsatzes in das Luftansaugrohr (15) des Motors und zur Erzeugung eines elektrischen Ausgangssignals mit einer Frequenz, die proportional zum Luftströmungsdurchsatz ist;
- eine Kurbelwellenabschaltbareinrichtung (17), um jedesmal dann einen elektrischen Ausgangsimpuls zu erzeugen, wenn die Kurbelwelle des Motors einen vorgegebenen Kurbelwinkel erreicht;
- einen Frequenzeiter (31) zur Durchführung einer Frequenzermittlung des Ausgangssignals vom Luftströmungssensor, wenn die Motorlast einen vorgegebenen Wert überschreitet, und zur Erzeugung eines Ausgangssignals mit der gleichen Frequenz wie der Frequenz des Ausgangssignals von der Luftströmungsmesseinrichtung, wenn die Motorlast unterhalb des vorgegebenen Wertes liegt; und
eine Steuerung (22) zur Berechnung des Luftströmungsdurchsatzes in die Zylinder des Motors auf der Basis des Ausgangssignals von dem Frequenzteller und von der Kurbelwinkel-abtasteinrichtung und zur Regelung des Kraftstoffeinspritzers in Abhängigkeit von dem berechneten Luftströmungsdurchsatz, der Temperatur des Motors und davon, ob der Motor im Leerlauf arbeitet.

2. Vorrichtung nach Anspruch 1, wobei die Steuerung (22) eine Einrichtung aufweist, um den Frequenzteller so zu steuern, daß er die Frequenzteilung durchführt, wenn die Anzahl von Ausgangsimpulsen des Luftstromungssensors zwischen aufeinanderfolgenden Ausgangsimpulsen des Kurbelwinkelsensors einen vorgegebenen Wert überschreitet, oder wenn die Periode der Ausgangsimpulse des Luftstromungssensors unterhalb des vorgegebenen Wertes liegt.

Revisions

1. Appareil de commande de combustible dans un système à injection d’un moteur à combustion interne (1), ledit système d’injection de carburant ayant au moins un injecteur de carburant (14) pour alimenter en carburant ledit moteur, et du type comprenant:
un moyen de détection de l’écoulement d’air (13) sensible au taux d’écoulement d’air à l’intérieur d’une pipe d’admission d’air (15) du dit moteur et produisant un signal électrique en sortie ayant une fréquence proportionnelle aux taux d’écoulement d’air;
caractérisé en ce qu’il comprend de plus un moyen de détection de l’angle du vilebrequin (17) pour produire un signal de sortie sous forme de pulsations électriques chaque fois que le vilebrequin dit moteur se trouve à un angle prédéterminé;
un moyen de division de fréquence (31) afin d’exécuter une division de la fréquence du signal de sortie dudit détecteur d’écoulement d’air lorsque la charge du moteur dépasse une valeur prédéterminée et pour produire un signal de sortie ayant la même fréquence que le signal de sortie dudit moyen de détection de l’écoulement d’air lorsque la charge du moteur est en dessous de la valeur prédéterminée; et
un moyen de contrôle (22) pour calculer le taux d’écoulement de l’air à l’intérieur des cylindres dudit moteur sur la base du signal de sortie dudit moyen de division de la fréquence et dudit moyen de détection de l’angle du vilebrequin et pour commander ledit injecteur de carburant en fonction du taux d’écoulement de l’air, de la température du moteur et de l’état au point mort ou non de celui-ci qui ont été calculés préalablement.

2. Appareil selon la révision 1, caractérisé en ce que ledit moyen de contrôle (22) comprend un moyen pour contrôler le moyen de division de la fréquence afin d’exécuter une division en fréquence lorsque le nombre de pulsations en sortie du détecteur d’écoulement d’air précité entre des pulsations en sortie consécutives du détecteur d’angle du vilebrequin vient à exéder une valeur prédéterminée ou lorsque la durée des pulsations de sortie du détecteur d’écoulement d’air est en dessous d’une valeur prédéterminée.
FIG. 6

100

reset

initialize

101

A/D conversion of water temperature (store as WT)

102

A/D conversion of battery voltage (store as VB)

103

N_e = 30/TR

104

F_a = A_N \cdot N_e / 30

105

K_p = f_1(F_a)

106

K_I = K_p \times f_2(WT)

107

T_D = f_3(VB)

FIG. 7

f_1

f_a
FIG. 9

1. IRQ
2. MEASURE TR
3. WAS THERE AFS INPUT DURING TR?
   - YES: TS = (TIME OF INTERRUPT) - (TIME OF AFS INPUT)
   - NO: TS = TR
4. ΔP = 156 \times \frac{TS}{TA}
5. ΔP > 156?
   - YES: ΔP \leftarrow 156
   - NO: ΔP = PD
6. PD < 0?
   - YES: ΔP = PD
   - NO: PD = 0
7. AN > Z?
   - YES: AN = Z
   - NO: AN = K1 \cdot AN + (1 - K1) \cdot PR
8. AN = K2 \cdot AN + (1 - K2) \cdot PR
9. PR = \begin{align*}
   &PR = PR + ΔP \\
   &PR = PR + 2ΔP
\end{align*}
10. IDLING SWITH
    - ON: 314a
    - OFF: 314b
11. AN = K1 \cdot AN + (1 - K1) \cdot PR
12. PR = \begin{align*}
   &PR = PR + ΔP \\
   &PR = PR + 2ΔP
\end{align*}
13. AN = K2 \cdot AN + (1 - K2) \cdot PR
14. SET TIMER TO Ti
15. TRIGGER TIMER
16. RET