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METHOD FOR ACCELERATION ENRICHMENT IN FUEL INJECTION SYSTEMS.

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Description

State of the Art

5 The present invention relates to fuel injection systems having acceleration enrichment (BA), of the kind described in the precharacterising clause of claim 1.

During acceleration conditions, it is conventional practice for the lengths of the injection pulses applied to the injection valves to be increased by an acceleration enrichment factor (FBA) in accordance with the expres-

$$10 \quad t_i = t_L \cdot FBA \cdot \pi F_{\text{kor}} + t_s \quad (1)$$

where t_L is a basic injection value proportional to $\frac{\text{air flow quantity } (Q_L)}{\text{engine speed } (n)}$

FBA is the acceleration enrichment factor

πF_{kor} is a combination of other correcting factors, well known in the art, and

15 t_s is a battery voltage correction factor.

In conventional injection systems, it is often possible to respond to rapid dynamic transition conditions by outputting a correspondingly increased injection time (t_i) only after a relatively long delay. This can be true even when a value for the acceleration enrichment factor (FBA) is actually available at the instant an acceleration enrichment requirement is detected and is taken into account in the next injection pulse. The reason for this is that, as a result of time delays in detecting the engine speed and the hot wire signal, as well as a result of pro-

20 gram running times, the required acceleration enrichment factor is applied to a value of t_L (basic load) which is too small, so that the excess quantity required at that instant is therefore not produced.

One known system, constructed in accordance with the precharacterising clause of claim 1, and having ignition pulses every 180° of crankshaft rotation, attempts to overcome this problem by providing a single igni-

25 tion-synchronous intermediate injection (RTIBA) between the last normal injection without acceleration enrichment (FBA) and the first enriched injection $t_i = t_L \cdot FBA + t_s$. This known example is illustrated in Figure 1 of the accompanying drawings. The value of this intermediate injection (RTIBA) is dependent on the prevailing value of the engine temperature (v_{Mot}) so that.

$$RTIBA = f(v_{\text{Mot}})$$

30 In the event that the engine has ignition pulses at 360° crank angles, then the acceleration enrichment factor (FBA) in this known system is increased once by a preselectable constant y , such that:

$$FBAUE = FBA \cdot y$$

In either case, after the single intermediate injection has taken place, the normal enrichment factor in accordance with equation (1) applies.

35 In another known system, a single intermediate injection is output in asynchronism with ignition immediately upon detection of an acceleration enrichment requirement. Should the detection of an acceleration enrichment requirement occur within the course of an existing injection period (t_i), then that period is extended by $RTIBA = f(v_{\text{Mot}})$.

A problem with the latter arrangements is that the program running time of the asynchronous main program controlling the fuel injection system varies considerably. It can therefore happen that the "FBAUE" is connected to a relatively high actual value of t_L and can thus lead in this case to a value for t_i which is too high. The length of an "increased" injection pulse t_i is thus dependent on detection and program running times. On the other hand it is conceivable that cases could arise in which the "normally" calculated output t_i remains too small because of extremely long program running times. The length of the first injection pulses (t_i) following accel-

45 eration enrichment detection can thus be more dependent on the widely varying dynamics of the program than on the desired prescribed values of the practical application.

It is also known (U.S. 4 126 107) to provide, upon detection of an acceleration enrichment condition, one or more additional injection pulses (RTIBA) of fixed length, independently of the primary injection pulses (t_i). A disadvantage of this arrangement is that the additional injection pulses are of fixed length and do not take

50 account of prevailing operating conditions.

A further known system (U.S. 3 673 989) provides, upon detection of an acceleration enrichment condition, a plurality of extra fixed length pulses in between normally calculated injection periods, the number of these pulses depending upon the demanded level of engine acceleration. Such a system has the disadvantage that it does not take into account the prevailing engine load and/or engine speed.

55 In a further known system, illustrated in Fig.3 of the accompanying drawings, a plurality of intermediate injections RTIBA are output in between and in addition to normally calculated injection periods $t_i (= t_L \cdot FBA + t_s)$ until the rotational speed of the engine has exceeded a threshold, which can be freely selected per datum. During this time, the intermediate injections RTIBA achieve an excess quantity of injected fuel. However, both

the excess quantity as well as the break-off criterion, after fulfilment of which only normally calculated T_L Periods are output, are formed by relatively rough methods in this known technique, which do not adapt the fuel enrichment sufficiently accurately to the acceleration demanded.

It is an object of the present invention to provide an acceleration enrichment arrangement which improves on the known arrangements and which is particularly suitable for use with injection systems of the type equipped with hot-wire air quantity detectors where the reaction times between hot-wire voltage (air requirement) and the calculation of the associated load t_L , as well as the calculated t_L and the output of t_i using this value of t_L , are considerable, sometimes perhaps of the order of 120 ms so that, in the event of rapid transition operations, this can lead to driving errors, or depending on the dimensioning of the acceleration enrichment data, to poor exhaust gas emission conditions.

Advantages of the Invention

The above object is achieved by adopting the features set forth in the characterising part of claim 1. This has the advantage that the first X acceleration enrichment injections are clearly defined, being dependent not on load (T_L) which takes some time to calculate, but rather on "load substitute variables" (such as engine speed n, hot wire voltage ULHM and change of hot wire voltage $\Delta ULHM$) which are available much more rapidly. X is a freely programmable datum. The initial injections do of course also depend, as in previous cases, on the engine temperature v_{mot} .

Drawings

The invention is described further, by way of example only, with reference to the accompanying drawings, in which:-

Fig 1 is a graphical representation of the operation of one known arrangement for achieving acceleration enrichment (BA);

Fig.2 is a graphical representation of the operation of an embodiment in accordance with the present invention; and

Fig.3 is a graphical representation of the operation of a second known arrangement.

In systems in accordance with the present invention, the reaction times which a computer requires to detect an actual basic duration of injection (= load) t_L are eliminated in that, once an acceleration requirement has been detected, initial injection pulses RTIBA are output in synchronism with the ignition pulses $(\mathcal{Z})$. The lengths of these initial pulses RTIBA are independent of engine load T_L but are arranged to be dependent upon "load substitute variables" such as the prevailing hot-wire voltage (ULHM), change in hot-wire voltage ($\Delta ULHM$) and engine speed (n). Thus, the load replacement variable $RTIBA = f(v_{mot}, n, ULHM, \Delta ULHM)$. It will be noted that the latter variables are available at the instant of acceleration enrichment detection. The length of the initial injection pulses is obtained in the simplest way in that the values of tables, which are dependent on v_{mot} , n, ULHM, $\Delta ULHM$ and are filed in the data region of the system, are traced (in part without interpolation) and linked to one another. In this way, long calculations of the load are avoided.

The maximum number of initial injection pulses RTIBA determined in this way is freely selectable. The length of the initial injections RTIBA, which are dependent on the motor temperature v_{mot} , as well as on the "load substitute variables" of the speed n, ULHM, $\Delta ULHM$, can be determined very quickly by accessing the table. Thus, such initial injections can be provided for the next X 180° crankshaft rotations or X 360° crankshaft rotations (X being freely selectable). Subsequently, following completion of X crankshaft revolutions (180° or 360°), the "normally calculated" injection period t_i is output again every 360° (crankshaft angle) in the normal manner in accordance with equation (I), i.e.:

$$t_{i_{norm}} = t_L \cdot FBA \cdot \pi F_{korr} + t_s$$

where πF_{korr} is a mathematical expression for the product of all other correction factors.

However, should the "normally calculated" value of t_i become larger than the "initial injections RTIBA" (load replacement variables), then $t_{i_{norm}}$ is immediately adapted, even if the preselected number of initial injections has not been reached. The dynamics of the control system is then once again able to cope with the external dynamic requirements.

Thus, the first X acceleration enrichment output values are clearly defined and applicable virtually immediately. They are not dependent on load t_L , but on "load substitute variables", which are available more rapidly.

Referring to Fig.2 of the drawings, in the illustrated case, three initial injections RTIBA occur before the normally calculated value of t_i becomes greater than the initial pulses RTIBA, i.e.

$$t_i > RTIBA = f(v_{Mot}, n, ULHM, \Delta ULHM)$$

The fourth injection pulse is then a "normally calculated" enrichment pulse in accordance with equation (1).

In practice the following initial injections (RTIBA) have been found appropriate:

$$RTIBA = f(ULHM, v_{Mot})$$

$$RTIBA = \begin{cases} f(ULHM) & \text{for } v_{Mot} < v_{threshold} \\ f(ULHM) \cdot a & \text{for } v_{Mot} > v_{threshold} \end{cases}$$

where $a < 1$.

15 Claims

1. A method of acceleration enrichment in an internal combustion engine fuel injection system of the type having a plurality of injection valves for the injection of fuel into the inlet manifold of the engine and which are adapted to be opened for variable periods (t_i) every 360° of crankshaft rotation in dependence upon engine load conditions, a hot-wire air quantity sensor for use in calculating prevailing engine load conditions, and means for providing fuel enrichment (BA) by extra operation of the injection valves when a predetermined acceleration condition of the engine is detected, characterised in that,

following detection of an acceleration enrichment requirement, $X > 1$ normal injections (t_i) are replaced by initial injections (RTIBA), whose length is -except for the first initial injection - independent of the instantaneous engine load (t_L), but depend upon engine variables detected at the time of detection of the acceleration enrichment requirement, the initial injections ending either when the predetermined number X has been reached or when the length of the normal injections (t_i) becomes greater than the length of the initial injections.

2. A method of acceleration enrichment as claimed in claim 1, wherein the length of the initial injection or injections (RTIBA), dependent on the engine temperature as well as on the "load substitute variables" of the speed n , hot wire voltage $ULHM$, change in hot wire voltage $\Delta ULHM$, are determined from stored look-up tables.

35 Patentansprüche

1. Verfahren zur Beschleunigungsanreicherung bei einer Brennkraftmaschine mit einem Einspritzsystem, das eine Mehrzahl von Einspritzventilen zur Einspritzung von Kraftstoff in das Ansaugrohr der Brennkraftmaschine aufweist, und die ausgelegt sind zum Öffnen für variable Perioden (t_i) für jede 360° Kurbelwellenumdrehung abhängig von Lastbedingungen, einem Hitzdrahtluftmassensensor zur Bereitstellung eines zu berechnenden gegebenen Maschinenlastzustandes, und Mitteln zum Liefern der Kraftstoffmenge (BA) durch eine gesonderte Ansteuerung der Einspritzventile, wenn eine vorbestimmte Beschleunigungsbedingung der Maschine erfaßt worden ist, dadurch gekennzeichnet, daß im Anschluß an das Erkennen eines Beschleunigungsanreicherungs-Erfordernisses $x > 1$ normale Einspritzungen (t_i) ersetzt werden durch Erst-Einspritzungen (RTIBA), deren Länge - außer für die erste Erst-Einspritzung - unabhängig von der momentanen Maschinenlast (t_L) ist, aber abhängig von Maschinenvariablen zum Zeitpunkt des Erfassens des Beschleunigungsanreicherungs-Erfordernisses, wobei die Erst-Einspritzungen dann enden, wenn entweder die vorbestimmte Anzahl X erreicht worden ist oder wenn die Länge der normalen Einspritzungen größer wird als die Länge der Erst-Einspritzungen.

2. Verfahren zur Beschleunigungsanreicherung nach Anspruch 1, wobei die Länge der Erst-Einspritzung oder die der Erst-Einspritzungen (RTIBA) abhängig ist von gespeicherten Kennfeldwerten ausgehend sowohl von der Maschinentemperatur als auch von "Ersatzlastgrößen" wie Drehzahl n , Hitzdrahtspannung $ULHM$, Änderung der Hitzdrahtspannung $\Delta ULHM$.

55 Revendications

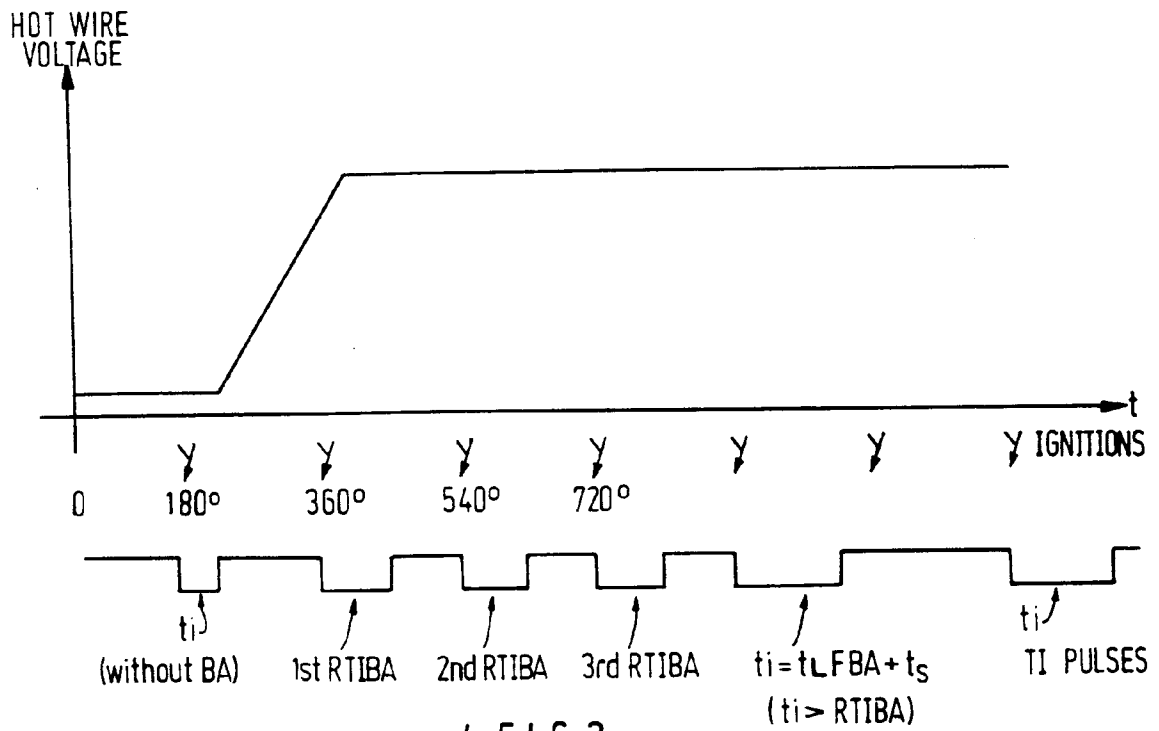
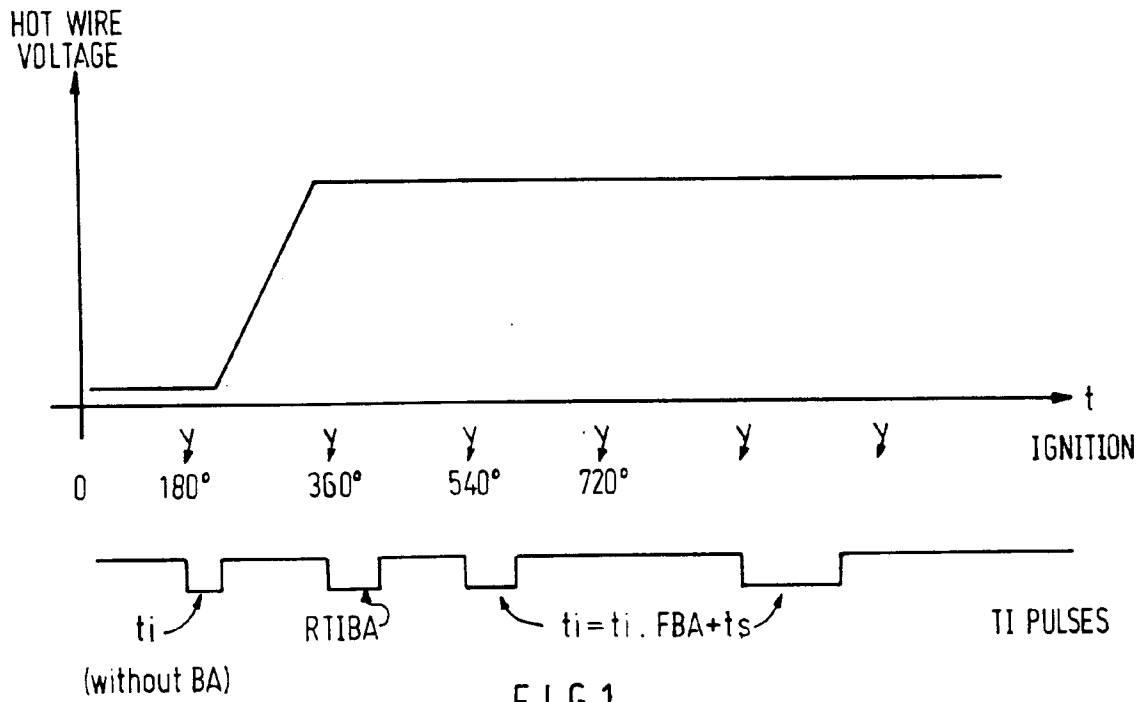
1. Procédé d'enrichissement à l'accélération dans un système d'injection de carburant pour moteur à combustion interne du type ayant un certain nombre de soupapes d'injection pour l'injection du carburant dans

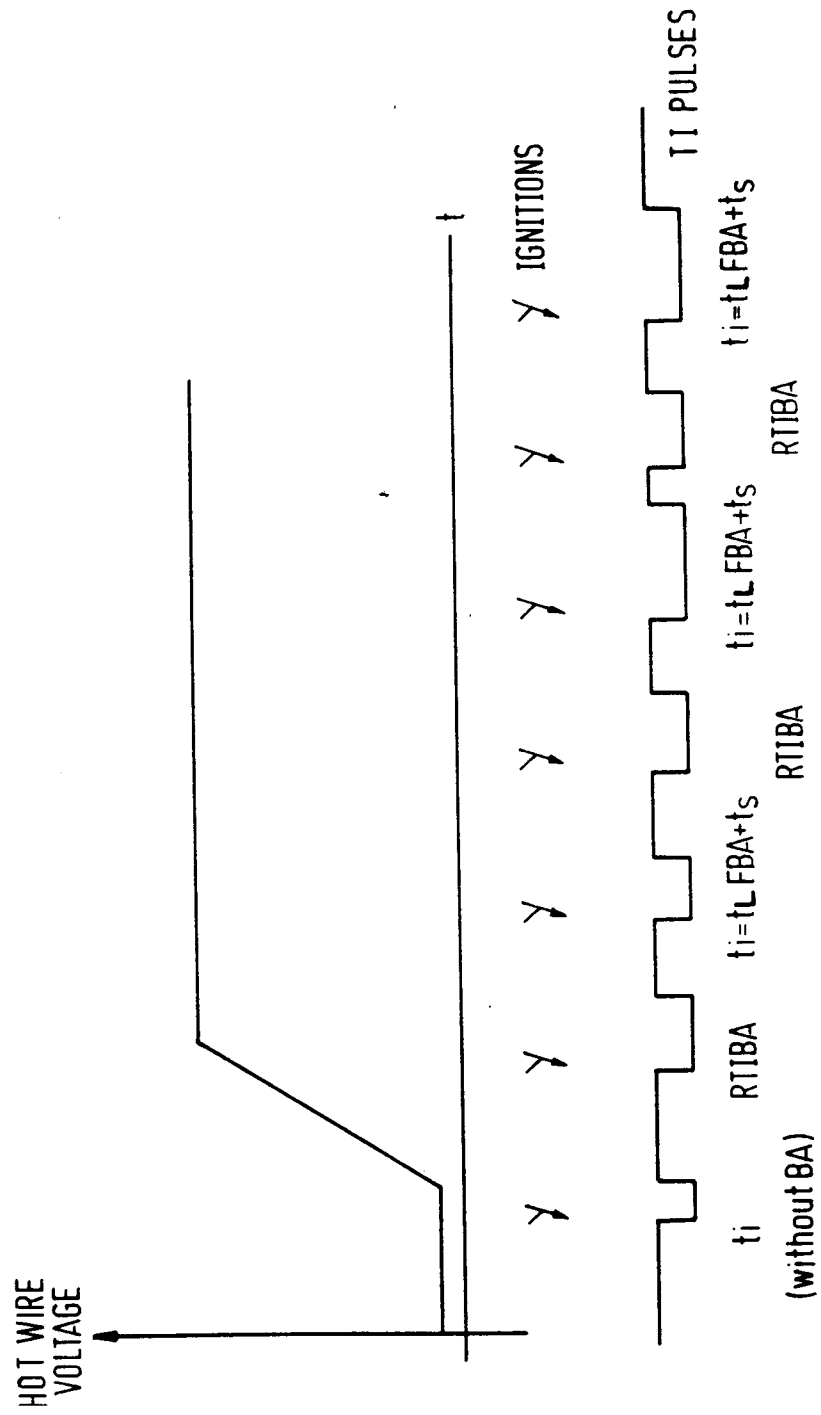
la pipe d'admission du moteur et qui sont conçues pour être ouvertes pendant des périodes de temps variables (t_i) à chaque rotation de 360° du vilebrequin en fonction des conditions de charge du moteur, un détecteur de quantité d'air à fil chaud pour l'utiliser en calculant les conditions de charge du moteur existantes et des moyens pour produire l'enrichissement du combustible (BA) par un fonctionnement exceptionnel des soupapes d'injection quand des conditions d'accélération prédéterminer du moteur sont détectées, procédé

caractérisé en ce

qu'après la détection d'une demande d'enrichissement à l'accélération, les injections (t_i) normales pour $X > 1$ sont remplacées par les injections initiales (RTIBA), dont la longueur est - sauf pour la première injection initiale - indépendante de la charge instantanée du moteur (t_L), mais fonction des variables du moteur détectées au moment de la détection de la demande d'enrichissement à l'accélération, les injections initiales se terminant soit quand le nombre X prédéterminé a été atteint ou quand la longueur des injections normales (t_i) devient plus grande que la longueur des injections initiales.

2. Un procédé d'enrichissement à l'accélération tel que revendiqué dans la revendication 1, dans lequel la longueur de l'injection ou des injections initiales (RTIBA), fonction de la température du moteur ainsi que des "variables de substitution de la charge" de la vitesse n , la tension ULHM du fil chaud, la variation de la tension du fil chaud $\Delta ULHM$ sont déterminés à partir de tables emmagasinées pour être reprises.



F16.3