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(54) **Synchronisation device without a cam-position sensor for an internal combustion engine**

Synchronisationsvorrichtung ohne Nockenwellenpositionssensor für eine innere Brennkraftmaschine

Dispositif de synchronisation sans un capteur de position de l'arbre à cames pour un moteur à combustion interne

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- **PATENT ABSTRACTS OF JAPAN vol. 013 no. 489 (M-888) ,7 November 1989 & JP-A-01 195975 (MITSUBISHI MOTORS CORP) 7 August 1989,**

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Description

[0001] The present invention relates to a synchronisation method for synchronising an Otto-cycle internal combustion engine of the kind defined in the preamble of Claim 1.

[0002] Most internal combustion engines for vehicles are currently supplied by a fuel-injection system controlled by an electronic engine management unit which almost always also controls the ignition. Many of the current systems have a precise angular reference over 360° of the engine crankshaft and not over 720° of the entire engine cycle (in the specific case of a four-cylinder, four-stroke engine, the most widely available model in current production).

[0003] However, in the case of engines which use individual ignition coils for each cylinder, of the so-called top-plug type, or for engines in which the cylinder phases are not symmetrical (for example, engines with five cylinders and V-engines with six cylinders of the so-called galloping type) it is essential to retain a precise reference at 720°.

[0004] In order to obtain this reference it is known to use sensors, for example, cam sensors, but these have the disadvantage of increasing the cost of the electronic engine management system.

[0005] DE-4 229 773-A and DE-4 242 419-A disclose methods of synchronisation of the initially-defined kind wherein it is detected whether the ignitions based on a first assumed engine phase lead to an acceleration; if not, the assumed engine phase is shifted by 360°.

[0006] The object of the present invention is to provide an improved synchronisation method of the afore-mentioned kind.

[0007] According to the present invention this object is achieved by a synchronisation method having the features defined in claim 1.

[0008] Further advantages and characteristics of the present invention will become apparent from the following detailed description provided as non-limitative example.

[0009] The essential idea on which the present invention is based is that of using an engine reference angle of 360° as the precise reference and of discriminating between odd and even 360° phases of a reference cylinder (which may be any one of the engine's cylinders) by using signals already available to the electronic engine management unit.

[0010] For this purpose a signal from circuits which supply information regarding the duration of the spark (or ionisation detection circuits) is used. These circuits, although known in the art, will become ever more necessary in the future to enable recent anti-pollution regulations to be complied with and to carry out diagnostic functions relating to the operation of the engine.

[0011] Ionisation detection circuits supply a signal proportional (in duration or amplitude) to the duration of the spark. However, the voltage for triggering and maintaining the combustion varies widely according to the pressure in the combustion chamber of the cylinder (approximately proportional to this) while the arc current of the spark is about constant. This means that, for a given energy supplied to the primary winding of the coil (for a given coil efficiency) the duration of the spark varies considerably. In practice, the spark lasts for a normal period of time if the cylinder is in compression while it lasts much longer if the cylinder is in the exhaust stroke.

[0012] In order to synchronise the engine, it thus suffices to cause ignition in one cylinder, selected as the reference cylinder, when this is in compression (or in exhaust given that this information is not known a priori) and to repeat the ignition after 360° so as to enable the two data relating to the spark duration to be compared. The spark of shorter duration is obtained when the stroke is, effectively, a compression stroke. Typically this procedure may be carried out on starting, and hence with the internal combustion engine being rotated by the starter motor, in a very short space of time since two full revolutions of the engine suffice for it to be completed. Moreover, the procedure may be carried out before the commencement of fuel injection into the cylinders. It is thus possible to initiate fuel injection (also phased) and to initiate the subsequent ignitions to start the engine after the synchronising procedure has been completed.

[0013] The strategy explained above may be improved to increase the certainty of discrimination by using several different cylinders as successive references (still during the first revolution of the engine and possibly fractions of the next revolution). The additional information thus obtained may confirm the first result or indicate the need for further monitoring if the results do not agree.

[0014] This same strategy may also be repeated with the engine running should there be an inexplicable drop in the engine speed (throttle valve angle greater than αO and engine deceleration greater than X revolutions/sec for a given αO and X).

[0015] In the absence of an ionisation circuit, the strategy may be carried out by using other signals which may be available to the engine's electronic management unit.

[0016] one signal which is always available, or can be deduced, is typically the correlation of the engine acceleration (positive or negative) with the throttle valve angle. This information can well be used in symmetrical engines instead of the said signal indicative of ionisation. By way of example, a four- or six-cylinder engine with pairs of cylinders out of phase by 360° (or even by 370-380°) is considered. In this case the engine may be started with two half-injections of fuel into almost opposed cylinders and with almost simultaneous firing of their ignitions. Thus ignitions are lost in the cylinder on the exhaust stroke but these ignitions (with the valve timing overlap typical of engines in current production) are not harmful. In these conditions the engine starts effectively.

[0017] At this point, immediately the throttle valve angle exceeds a predetermined threshold (for example, throttle valve angle greater than βO, which corresponds, in practice, to a specific required torque, with the engine already started (rotational speed greater than Y revolutions/sec for given βO and Y), a search strategy may be undertaken to effect discrimination between even and odd 360° angles.

[0018] This strategy may comprise effecting ignition every 720° for all cylinders, with a random choice of association with the 720° reference, that is, a random choice between even 360° angles and odd 360° angles. If the engine decelerates beyond a predetermined limit, the opposite association is tested, that is the choice between even 360° angles and odd 360° angles is reversed. At the end of this test, the correct reference is thus identified. This strategy may cause a gap in the engine operation but this situation is not dangerous and is scarcely perceptible to the driver since the engine is being started.

[0019] Alternatively, a strategy for recognising the even 360° angles and odd 360° angles may be carried out independently of the position of the throttle valve when the engine is in the transitional stage between the disconnection of the starter motor and the attainment of idling conditions (about 400-600 revolutions per minute).

[0020] Once the 720° phase angles have been recognised by means of one of the said strategies, both the injection and the ignition are controlled with the use of all this information (thus injection may be phased). Even then, one of the above-mentioned strategies may possibly be repeated with the engine running should the engine speed drop inexplicably.

[0021] The strategies explained above may be used alone, in combination (for example to increase reliability should the ionisation detection circuit fail) or even in association with a cam-position sensor in order to considerably increase the general reliability of the engine control system.

[0022] Another source of information which can be used to determine the 720° phase reference is provided by pressure sensors in the cylinder, if these are present, since these enable direct determination of whether the reference cylinder is in compression or exhaust.

[0023] Naturally, the principle of the invention remaining the same, the constructional details and embodiments may be varied widely with respect to that described and illustrated without thereby departing from the scope of the present invention.

Claims

1. A method for synchronising an Otto-cycle internal combustion engine,
the said engine having a throttle valve, and an ignition system and a fuel supply system controlled by at least one electronic engine management unit, and sensor means for providing said electronic unit with a first reference signal indicative of the angular position of the engine crankshaft over 360°,
the method being adapted to generate a second reference signal indicative of the actual phase angle of at least one cylinder of the said engine so as to allow, in combination with the first reference signal, the angular position of the engine crankshaft to be determined over 720°;
characterised in that it includes the steps of:

- generating, a priori, a test reference signal, assumed to be indicative of the angular position of the engine crankshaft over 720°, and corresponding to a first one of the two possible ways of association of odd and even intervals of 360°;
- causing an ignition every 720° in each cylinder of the engine on the basis of said test reference signal generated a priori;
- checking the consistency of the engine acceleration (positive or negative) with the angle of opening of the engine throttle valve;
- when the engine acceleration is consistent with the angle of opening of said throttle valve, adopting said test reference signal as the said second reference signal, and
- when the engine acceleration is inconsistent with the throttle valve angle, adopting as the said second reference signal a signal corresponding to the second way of association of odd and even intervals of 360°.

2. A method according to Claim 1, wherein said test reference signal, generated a priori, is generated in a random manner.

Patentansprüche

1. Verfahren zum Synchronisieren eines Ottomotors, wobei der Motor eine Drosselklappe, ein Zündsystem und ein Kraftstoff-Zuführsystem, die von zumindest einer elektronischen Motor-Betriebseinheit gesteuert werden, sowie eine Fühlereinrichtung besitzt, um die elektronische Einheit mit einem ersten Bezugssignal anzusteuern, das die Winkelstellung der Kurbelwelle des Motors über 360° anzeigt,
wobei das Verfahren so ausgelegt ist, um ein zweites Bezugssignal zu erzeugen, das den momentanen Phasenwinkel von zumindest einem Zylinder des Motors anzeigt, um in Kombination mit dem ersten Bezugssignal die Winkelstellung der Kurbelwelle des Motors über 720° bestimmen zu können;
dadurch gekennzeichnet, dass das Verfahren folgende Schritte aufweist:

- a priori erzeugen eines Prüf-Bezugssignals, das dazu dient, um die Winkelstellung der Kurbelwelle des Motors über 720° anzuzeigen, und das einer ersten von zwei möglichen Arten entspricht, die ungeradzahligen und geradzahligen Intervallen von 360° zugeordnet sind;
- hervorrufen einer Zündung alle 720° in jedem Zylinder des Motors aufgrund des Prüf-Bezugssignals, das a priori erzeugt wurde;
- prüfen, ob die Motorbeschleunigung (positiv oder negativ) mit dem Öffnungswinkel der Drosselklappe des Motors in Einklang steht;
- wenn die Motorbeschleunigung mit dem Öffnungswinkel der Drosselklappe in Einklang steht, annehmen des Prüf-Bezugssignals als das zweite Bezugssignal, und
- wenn die Motorbeschleunigung nicht mit dem Winkel der Drosselklappe in Einklang steht, annehmen eines Signals als zweites Bezugssignal, das der zweiten Art der Zuordnung von ungeradzahligen und geradzahligen Intervallen von 360° entspricht.

2. Verfahren gemäß Anspruch 1, wobei das Prüf-Bezugssignal, das a priori erzeugt wird, wahlfrei erzeugt wird.

Revendications

1. Procédé de synchronisation d'un moteur à combustion interne, à allumage par étincelle ;

ledit moteur comprenant un papillon des gaz et un système d'allumage ainsi qu'un système d'arrivée de carburant contrôlé par au moins une unité de gestion de moteur électronique, et des moyens de détecteur pour fournir à ladite unité électronique un premier signal de référence indiquant la position angulaire du vilebrequin du moteur sur une plage de 360° ;

le procédé étant adapté pour produire un deuxième signal de référence indiquant l'angle de phase réel d'au moins un cylindre dudit moteur de manière à permettre, en combinaison avec le premier signal de référence, à la position angulaire du vilebrequin du moteur d'être déterminée sur une plage de 720° ;

caractérisé en ce qu'il comprend les étapes consistant à :

- générer, a priori, un signal de référence test, qui est supposé indiquer la position angulaire du vilebrequin du moteur sur une plage de 720°, et correspondant à une première parmi les deux façons possibles d'associer des intervalles pairs et impairs de 360° ;
- provoquer un allumage tous les 720° dans chaque cylindre du moteur sur la base dudit signal de référence test produit a priori ;
- vérifier la cohérence de l'accélération du moteur (positive ou négative) avec l'angle d'ouverture au niveau du papillon des gaz du moteur ;
- lorsque l'accélération du moteur est cohérente avec l'angle d'ouverture dudit papillon des gaz, adopter ledit signal de référence test en tant que dit deuxième signal de référence ; et
- lorsque l'accélération du moteur n'est pas cohérente avec l'angle d'ouverture du papillon des gaz, adopter en tant que dit deuxième signal de référence un signal correspondant à la deuxième façon d'associer des intervalles pairs et impairs de 360°.

2. Procédé selon la revendication 1, dans lequel ledit signal de référence test, généré a priori, est produit d'une manière aléatoire.