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(54) **CONTROL ARRANGEMENT OF AN ELECTRO-HYDRAULIC GAS EXCHANGE VALVE ACTUATION SYSTEM**

VORRICHTUNG ZUR KONTROLE EINER ELEKTROHYDRAULISCHEN VENTILBETÄTIGUNGSENRICHTUNG

AMÉNAGEMENT DE COMMANDE D'UN SYSTÈME D'ACTIONNEMENT DE SOUPAPE D'ÉCHANGE GAZEUX ÉLECTRO-HYDRAULIQUE

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Description

Field of Technology

[0001] This invention relates to an arrangement to control an electro-hydraulic gas exchange valve actuation system (EHVA system). EHVA systems are used with internal combustion engines.

Background

[0002] An internal combustion engine comprises cylinders wherein combustion of fuel occurs. Combustion air is fed to the cylinders through intakes valves, and exhaust gases are routed out of the cylinders through exhaust valves. The valves are driven by actuators that are controlled by hydraulic valves. The hydraulic valves are directed electrically in turn. This kind of arrangement is called as an electro-hydraulic gas exchange valve actuation system i.e. EHVA system.

[0003] The nonlinear dynamics and the delay of the EHVA system provide difficulties in controlling the system. A simple feedback controller cannot adjust EHVA in a required accuracy. Therefore more complex and advanced controllers are used. However, tuning of parameters of such a controller is very time consuming, which make the use of the advanced controller impractical in many cases.

Short Description of Invention

[0004] The aim of the invention is to alleviate the said control problems. The aim is achieved in a way described in the independent claim. The inventive control arrangement comprises a feedback controller, in an iterative learning controller, and a delay controller. The feedback controller drives EHVA system. The EHVA systems means in this context the system needed to drive one valve or the system driving several valves. For simplicity, it is easier and more understandable to think about the driving of one valve. It is clear that the drive of one valve is expandable to the system driving several valves.

[0005] The iterative learning controller drives the feedback controller by adjusting reference signal, and the delay compensator drives the iterative learning controller by modifying the reference signal to be adjusted. Thus, the iterative learning controller provides new reference signal to the feedback controller. The arrangement comprises also a valve lift profile element to provide a lift profile to the iterative learning controller and to the delay compensator.

[0006] The iterative learning controller comprises an input interface to receive an actual valve lift data of the valve actuation system, an error memory unit to keep valve position tracking errors in memory, an output command memory unit to keep output commands of the iterative learning controller in memory, and an iteration actuating arrangement for switching on and off an iteration process of the iterative learning controller.

[0007] The delay compensator comprises a second input interface to receive the actual valve lift data, a third interface to receive crank angle data of an engine, and a comparator. The comparator compares the actual valve lift and crank angle data pair to a corresponding data pair of the lift profile and performs shift signal as response to the comparison, and transmits the shift signal to the iterative learning controller to drive the iteration actuation arrangement. The iteration process is arranged to stop in case of the shifting the lift profile and to restart when a next cycle of the valve actuation system starts.

[0008] Three controllers of the arrangement are arranged in such a way that they do not disturb each other when running.

Drawings

[0009] In the next, the invention is described in more detail with help of the figures of the attached drawings in which

Figure 1 shows an example of an inventive arrangement partly,
Figure 2 shows an example of an inventive arrangement,
Figure 3 shows an example of delay compensation according to the invention,
Figure 4 shows an example of the command memory unit of the invention, and
Figure 5 shows an example of the error memory unit of the invention.

Description

[0010] Figure 1 shows an example of the iterative learning controller 1 (ILC) of the invention and how it can be connected to the other parts of the invention. In this example, ILC controller drives P-controller 2, i.e. provides new reference to P-controller, but it should be noted that the controller being driven can be any position or tracking controller, for example, PI-, PD-, PID-, or a state controller and feed-forward loops. The P-controller comprises a gain element 6 and an element

7 for adjusting a reference signal transmitted from ILC controller 1 by a feedback signal from the valve actuation system 3 i.e. EHVA system. The feedback signal contains actual valve lift data 5. This data is also transmitted to ILC controller 1 and to the delay controller 16, i.e. the delay compensator (Fig. 2). P-controller sends a control signal 4 for lifting the valve in EHVA.

[0011] ILC controller 1 has an interface 24 for receiving said actual valve lift data. As can be noticed, this description does not refer to all interfaces of the elements of the invention. For example, there exist interfaces between the lift profile element 13 and ILC 1, and between the delay compensator 16 and ILC1 for transmitting signals among them, which are not specifically referred. Further, since a number of the interfaces depend on the structure of a real embodiment, it should be noted that one interface can actually take care of several signals to be sent or received. So, connections illustrated between the elements in the figures indicate that there exists an interface in practice through which the connection or connections can be created.

[0012] The ILC tracking control method is a method where the control system is learning from previous repeated control trials, weather succeed or failed. The observed error of previous repetition is used to adjust the command in current run so that command actually produces the desired trajectory. This is realized through memory based learning. The simplest ILC scheme is presented in Eq. 1, where u is the control input, i iteration index, q constant learning gain, and Δy tracking error.

$$u_{i+1}(t) = u_i(t) + q\Delta y_i(t) \qquad (1)$$

[0013] Thus, the tracking error is measured at every data point, and saved in the memory as a curve similar than the valve lift curve. In next repetitive round, 'the error curve' of the previous round is added to the previously used reference valve lift curve and the modified curve is also saved. When the process goes on, the valve lift curve gradually transforms to the shape, which results the minimum tracking error of the system.

[0014] So, the lift profile element 13 provides a desired valve lift data to ILC controller 1 and an error calculator element 8 calculates the tracking error from the actual valve lift and the desired valve lift, and transmits the position error to the error memory unit 9. The error memory unit 9 keeps the tracking error in memory. A gain element 10 receives the position error from the error memory unit, multiplies the position error with a gain factor. The gain is adjustable by the iteration actuation arrangement. The gained tracking error is received and summed in the summing element 11 with the latest control output signal to be transmitted to the P-controller 2 and to the command memory.

[0015] The control output signals, i.e. reference valve lift for the P-controller 2, are kept in memory in the command memory unit 12 from which the latest command (the ILC control output) is delivered to the summing element 11.

[0016] The nature of the ILC is, that at some point, the tracking error stops decreasing, and may start to grow. The error cannot go to zero during the whole event due the dynamics of the system, but the learning process continues to modify the reference curve. At some point, the system cannot follow increasing reference value properly, and the error is also increasing. In the invention that problem is solved by stopping the learning process when the error is inside the predefined tolerance. The learning process can be stopped and restarted, for example, by change of learning gain 10 value. If the error is too large, the engine needs to be protected. Therefore the inventive arrangement may contain a tracking error indication unit 28 for following the error. If the error is too large, the alarm can be made in the alarm monitoring unit 29 and the valve actuation system 3 can be stopped or run to a certain state.

[0017] Figure 2 shows the inventive arrangement having the delay compensator 16. It was found that delay of the valve actuation system may cause a large part of the tracking error. Therefore the controlling arrangement is continuously watching position difference (lift difference) as a crank angle function between desired and actual position. When the compensator detects difference larger than, for example, 1 CA degree, the arrangement shifts valve lift curve, i.e. the lift profile fed to the controller to the desired direction. This is helpful feature during the start and stop sequences of the diesel engine, when rotational speed is changing rapidly, and other occasional variation of the engine RPM during the run.

[0018] So, the delay compensator 16 comprises a second input interface 25 to receive the actual valve lift data, a third interface 30 to receive crank angle data 20 of an engine, a comparator 17 to compare the actual valve lift and crank angle data pair to a corresponding data pair of the lift profile and to perform shift signal 15, 23 as response to the comparison, and to transmit 15, 23 the shift signal to the valve lift profile element 13 to keep the used compensation value in a memory, and to transmit the shift signal to the iterative learning controller 1 to drive the iteration actuation arrangement 21,23'. Memorized delay value is used when profile is reseted or new profile is changed. Value of the delay compensation is then send to the command memory unit 12 with curve initialization. For initialize the profile comparison element 17 or in case of profile change the lift profile element 13 is arranged to transmit the relevant lift profile 26 to the comparison element 17. The iteration process is arranged to stop in case of the shifting the lift profile and to restart when shifting the lift profile is completed.

[0019] As can be seen in Figure 1, the iterative learning controller 1 comprises an error memory unit 9 to keep valve position tracking errors in memory, an output command memory unit 12 to keep output commands of the iterative learning controller in memory, and also an iteration actuating arrangement (21, 14', 18' 19', 22', 23') for switching on and off an iteration process of the iterative learning controller. In the figures the arrangement is illustrated in a centralized manner, i.e. having an element 21 to receive the shift signal 23, the change info of the lift profile 14, and the position error 19. The element is arranged to switch on and off the iteration process by guiding the command memory 12 and the elements (9, 10) handling the position errors. The arrangement can also be realized in a distributed fashion in which case there is no central element 21 but similar functionality is located in the elements to be actuated. The signals needed can be delivered directly to these elements, not transmitted through the lift profile element 13 and/or central element 21.

[0020] A reference number of a signal indicates a certain signal. For example, reference number 23 indicates the profile shifting signal from the delay compensator 16 to the ILC controller 1. The received shifting signal starts the switching actions of the elements in ILC. These actions and corresponding actuation signals are referred with the same number having ' -mark, like 23'. So, number 18 means that the iterative learning process can started manually', in which case the learning gain 10 is actuated 18' to have a gain value above zero.

[0021] In case of the shifting the lift profile due to the delay of the actuation system, the learning gain 10 is actuated to zero, which means that the learning stops. Also vectors in the command memory unit 12 and in the error memory unit are shifted, which is explained later. When ILC process is not active during the shift, it avoids possible negative interactions between delay compensation and ILC process.

[0022] Figure 3 illustrates an example of a lift profile and how it is shifted. A lift value is on Y-axes and a crank angle value on X-axes. So, in a certain crank angle value, the valve is lifted a certain amount. The solid curve 31 is a reference lift profile. If a real measurement from the valve actuation system shows a lift value Y1 in crank angle value X2, it can be noticed from curve 32, with dashed line, that the Y1 should be arisen in crank angle X1. This means that the reference lift profile should be shifted in order to matching the measurement and the reference. More than one measurement point can be compared before making a decision for shifting. So, the file comparison element makes that comparison and provides profile shifting info to the lift profile and the ILC 1.

[0023] So, for shifting the lift profile and vector elements of the command memory unit and the error memory unit can be indexed by crank angle values. If the comparison of the comparator 17 shows that the measured crank angle and the desired crank angle value with a measured lift position differs enough, the indexes of the lift profile and said vectors are shifted in such a way that the difference decreases.

[0024] Figure 4 shows the command memory unit 12 in more detail. The unit comprises a vector element 41 in which the ILC output commands are kept in memory in a vector form. If the shifting occurs, the unit 9 receives a shifting signal 23' to shift a crank angle index of the vector. In this way the values of the vectors are shifted, which corresponds the shift illustrated in Figure 3 By shifting the vector the error of the iterative learning is kept in a reasonable level in the next round. So, for taking care of the shift, the command memory unit comprises a shift element 42 to receive the shift signal and to shift the content of the first vector element as response to the received shift signal.

[0025] Figure 5 shows the error memory unit 9 in more detail. The unit comprises vector elements 51 in which the tracking errors are kept in memory in vector forms. If the shifting occurs, the unit 9 receives a shifting signal 23' to shift a crank angle index of the vectors. In this way the values of the vectors are shifted, which corresponds the shift illustrated in Figure 3. By shifting the vectors the error change of the iterative learning is kept in a reasonable level in the next round and synchronized with lift profile inside command memory unit 12. So, for taking care of the shift, the error memory unit comprises a shift element 52 to receive the shift signal and to shift the contents of the second vector elements as response to the received shift signal.

[0026] The error vectors can be made for errors calculated in different ways. The different errors can be uses for different purposes.

[0027] The crank angle data is received by the command memory unit and the error memory unit for get a real crank angle value for the shift actions.

[0028] The error can be observed as an average during the valve lift or certain part of the valve lift. When the average error is inside the tolerance range, i.e. in a certain limited range around a desired error value, ILC iteration process is stopped 22, 22'. If average error goes outside of the tolerance, i.e. outside a second range around the desired error value, ILC iteration process is restarted 22. 22'. If the valve position tracking error is outside a third range around the desired error value, the iteration process is reset. In that third case the error is considered to be so large, that something in ILC process has went wrong, and is better to return in initial valve lift curve and start the ILC process from the very beginning.

[0029] The error can be calculated in different ways as well. For example, a sum of the error can be measured during the whole valve stroke. Or instead of the sum, mean square error can be used. Error for one point of the lift profile can also be calculated. So, different type of error vectors can be calculated simultaneously for different purposes. Thus the iteration process for a certain error point can be stopped after the error has achieved a certain range, and the iteration process for another error type still continues. For example, if the one-point-error iteration is stopped, the error is in an acceptable level in this particular point, but the sum-error iteration continues, since it has not achieved an acceptable level.

[0030] The inventive embodiment can also comprise a feature which allows changing the lift curve during the engine run. Due the memory-based system of the ILC, right timed shifting between the curves is important. The arrangement allows numerous preloaded lift curves, which the user can bring into play at any time. The arrangement takes care that no overshoots between the curves happens, and change is made in a proper moment.

[0031] A command for the profile change on the fly is given 14 to the arrangement. After the command for the change is given, the controller waits until the gas exchange valve is certainly closed, and changes the profile after that. Because the ILC process uses error signal of previous work cycle, the change can be used only after one work cycle, i.e. one cycle of the valve. At the same time, correct target reference fed to tracking error system is delayed by one cycle. If the tracking error with new reference curve is keeping under the third error range mentioned above, the delay compensation is kept at the last known value, memorized in the valve lift profile element 13. This way the error is not necessarily grown very high even the new profile is a basic unlearned profile in the beginning of the change. Therefore the change of the valve timing causes no alert.

[0032] So, referring to Figure 1 the valve lift profile element 13 comprises a number of lift profiles, and change of the lift profile is arranged to be run when receiving a command 14 for the change, in which case the iteration process is arranged to stop when the valve position indicates the valve being closed, and to restart after the cycle of the valve actuation system, i.e. the cycle of the valve. For changing the profile the ILC comprises necessary elements for directing 14' the new profile the command memory unit. The same elements can take care of the restart of the ILC if the tracking error is too large 19, 19'.

[0033] The feedback controller 2, the iterative learning controller 1, the delay compensator 16, and the valve lift profile element 13 can be implemented in one entity 27, which entity comprises connections among the controllers, compensator and the profile element, and interfaces for the valve actuation system and the internal combustion engine. A grouping of the elements, components and functions of the invention can be made in many ways. An implementation of the invention can be made, for example, by printed circuits or software programs installed on a computer device.

[0034] It is clear from this description that the invention can be obtained in many different ways in the scope of the claims.

Claims

1. A control arrangement of an electro-hydraulic gas exchange valve actuation system, which arrangement comprises a feedback controller (2) to drive the valve actuation system, **characterized in that** the arrangement further comprises

- an iterative learning controller (1) to drive the feedback controller,
- a delay compensator (16) to drive the iterative learning controller, and
- a valve lift profile element (13) to provide a lift profile to the iterative learning controller and to the delay compensator,

the iterative learning controller (1) comprising

- an input interface (24) to receive an actual valve lift data (5) of the valve actuation system,
- an error memory unit (9) to keep valve position tracking errors in memory,
- an output command memory unit (12) to keep output commands of the iterative learning controller in memory, and
- an iteration actuating arrangement (21, 14', 18' 19', 22', 23') for switching on and off an iteration process of the iterative learning controller,

the delay compensator (16) comprising

- a second input interface (25) to receive the actual valve lift data,
- a third interface (30) to receive crank angle data (20) of an engine, and
- a comparator (17) to compare the actual valve lift data (5) and crank angle data (20) pair to a corresponding data pair of the lift profile, to provide shift signal as response to the comparison, and to transmit the shift signal to the iterative learning controller (1) to drive the iteration actuation arrangement (21,23'), which iteration process is arranged to stop in case of the shifting the lift profile and to restart iteration process after completion of the shifting the lift profile.

2. A control arrangement according to claim 1, **characterized in that** the command memory unit (12) comprises a first vector element (41) to keep the output commands, and a first shifting element (42) to receive the shift signal and to shift the content of the first vector element as response to the received shift signal, and the error memory unit (9) comprises second vector elements (51) to keep the tracking errors, and a second shifting element (52) to receive the shift signal and to shift the contents of the second vector elements as response to the received shift signal.

3. A control arrangement according to claim 2, **characterized in that** the lift profile and said first and second vector element are indexed by crank angle values and if the comparison of the comparator (17) shows that the measured crank angle and the desired crank angle value with a measured lift position differs enough, said vectors are shifted in such a way that the difference decreases.

4. A control arrangement according to claim 3, **characterized in that** if the valve position tracking error is in a certain limited range around a desired error value, the iteration process is discontinued, and
if the valve position tracking error is outside a second range around the desired error value, the iteration process is restarted, and
if the valve position tracking error is outside a third range around the desired error value, the iteration process is reset.

5. A control arrangement according to claim 4, **characterized in that** the valve lift profile element (13) comprises a number of lift profiles, and change of the lift profile is arranged to be run when receiving a command for the change, in which case
the iteration process is arranged to stop when the valve position indicates the valve being closed, and to restart after the cycle of the valve actuation system.

6. A control arrangement according to claim 4 or 5, **characterized in that** the iterative learning controller (1) comprises an error calculator element (8) to calculate the valve position tracking error from the actual valve lift data and the lift profile in use and to transmit the position error to the error memory (9), and
a gain element (10) to receive the position error from the error memory, to multiply the position error with a gain factor, which gain is adjustable by the iteration actuation arrangement and
a second summing element (11) to receive the multiplied position error and the latest output command from the command memory, to sum the received position error and the output command, and to transmit the sum to the feedback controller (2) and to the command memory.

7. A control arrangement according to claim 6, **characterized in that** the iteration actuating arrangement (21, 22) comprises an element (21) to receive the shift signal, the change of the lift profile, and the position error, which element is arranged to switch on and off the iteration process by guiding the command memory (12 and the elements (8, 9, 10, 11) handling the position errors.

8. A control arrangement according to claim 7, **characterized in that** the feedback controller (2), the iterative learning controller (1), the delay compensator (16), and the valve lift profile element (13) are implemented in one entity, which entity comprises connections among the controllers, compensator and the profile element, and interfaces for the valve actuation system and the internal combustion engine.

9. A control arrangement according to claim 7 or 8, **characterized in that** the shift of the lift profile occurs when the difference between a desired crank angle position and an actual position is larger than 0,5 degree.

10. A control arrangement according to claim 9, **characterized in that** the feedback controller (2) is P-, PI-, PD-, PID-, or a state controller.

Patentansprüche

1. Steuereinrichtung eines elektrohydraulischen Gasaustauschventil-Betätigungssystems, wobei die Einrichtung ein Rückkopplungssteuerglied (2) aufweist, um das Ventilbetätigungssystem zu betreiben, **dadurch gekennzeichnet, dass** die Einrichtung ferner aufweist:

- ein iterativ lernendes Steuerglied (1) zum Betreiben des Rückkopplungssteuerglieds,
- einen Verzögerungskompensator (16) zum Betreiben des iterativ lernenden Steuerglieds, und
- ein Ventilhubprofilelement (13) zum Bereitstellen eine Hubprofils für das iterativ lernende Steuerglied und den Verzögerungskompensator,

wobei das iterativ lernende Steuerglied (1) aufweist:

- eine Eingabeschnittstelle (24) zum Empfangen aktueller Ventilhubdaten (5) des Ventilbetätigungssystems,
- eine Fehlerspeichereinheit (9) zum Speichern von Ventilpositions-Nachführungsfehlern im Speicher,
- eine Ausgabebefehl-Speichereinheit (12) zum Speichern von Ausgabebefehlen des iterativ lernenden Steuerglieds im Speicher und
- eine Iterationsausführungseinrichtung (21, 14', 18', 19', 22', 23') zum Ein- und Ausschalten eines Iterationsprozesses des iterativ lernenden Steuerglieds,

wobei der Verzögerungskompensator (16) aufweist:

- eine zweite Eingabeschnittstelle (25) zum Empfangen der aktuellen Ventilhubdaten,
- eine dritte Schnittstelle (30) zum Empfangen von Kurbelwinkeldaten (20) eines Motors, und
- einen Komparator (17) zum Vergleichen des aktuellen Paars von Ventilhubdaten (5) und Kurbelwinkeldaten (20) mit einem entsprechenden Datenpaar des Hubprofils, um im Ergebnis des Vergleichs ein Verschiebungssignal bereitzustellen und das Verschiebungssignal dem iterativ lernenden Steuerglied (1) zu senden, um die Iterationsausführungseinrichtung (21, 23') zu betreiben, wobei der Iterationsprozess eingerichtet ist, in dem Fall der Verschiebung des Hubprofils anzuhalten und nach dem Abschluss der Verschiebung des Hubprofils den Iterationsprozess neu zu starten.

2. Steuereinrichtung nach Anspruch 1, **dadurch gekennzeichnet, dass** die Befehlsspeichereinheit (12) aufweist: ein erstes Vektorelement (41), um die Ausgabebefehle zu speichern, und ein erstes Verschiebungselement (42), um das Verschiebungssignal zu empfangen und den Inhalt des ersten Vektorelements in Reaktion auf das empfangene Verschiebungssignal zu verschieben, und die Fehlerspeichereinheit (9) aufweist: zweite Vektorelemente (51), um die Nachführungsfehler zu speichern, und ein zweites Verschiebungselement (52), um das Verschiebungssignal zu empfangen und die Inhalte der zweiten Vektorelemente in Reaktion auf das empfangene Verschiebungssignal zu verschieben.

3. Steuereinrichtung nach Anspruch 2, **dadurch gekennzeichnet, dass** das Hubprofil und das erste und zweite Vektorelement durch Kurbelwinkelwerte indiziert werden und die Vektoren dann, wenn der Vergleich des Komparators (17) zeigt, dass sich der gemessene Kurbelwinkel und der gewünschte Kurbelwinkel bei einer gemessenen Hubposition hinreichend unterscheiden, derart verschoben werden, dass die Differenz abnimmt.

4. Steuereinrichtung nach Anspruch 3, **dadurch gekennzeichnet, dass** der Iterationsprozess unterbrochen wird, wenn der Ventilpositions-Nachführungsfehler in einem bestimmten begrenzten Bereich um einen gewünschten Fehlerwert herum liegt, und
der Iterationsprozess neu gestartet wird, wenn der Ventilpositions-Nachführungsfehler außerhalb eines zweiten Bereiches um den gewünschten Fehlerwert herum liegt,
der Iterationsprozess zurückgesetzt wird, wenn der Ventilpositions-Nachführungsfehler außerhalb eines dritten Bereiches um den gewünschten Fehlerwert herum liegt.

5. Steuereinrichtung nach Anspruch 4, **dadurch gekennzeichnet, dass** das Ventilhubprofilelement (13) eine Anzahl von Hubprofilen aufweist und eine Veränderung des Hubprofils vorzunehmen ist, wenn ein Befehl für die Veränderung empfangen wird, wobei in diesem Fall
der Iterationsprozess eingerichtet ist anzuhalten, wenn die Ventilposition anzeigt, dass das Ventil geschlossen ist, und nach dem Zyklus des Ventilbetätigungssystems neu zu starten.

6. Steuereinrichtung nach Anspruch 4 oder 5, **dadurch gekennzeichnet, dass** das iterativ lernende Steuerglied (1) aufweist:

ein Fehlerberechnungselement (8) zum Berechnen des Ventilpositions-Nachführungsfehlers aus den tatsächlichen Ventilhubdaten und dem verwendeten Hubprofil und zum Senden des Positionsfehlers an den Fehlerspeicher (9), und
ein Verstärkungselement (10) zum Empfangen des Positionsfehlers aus dem Fehlerspeicher, zum Multiplizieren des Positionsfehlers mit einem Verstärkungsfaktor, wobei die Verstärkung durch die Iterationsausführungseinrichtung anpassbar ist und
ein zweites Summierelement (11) zum Empfangen des multiplizierten Positionsfehlers und des letzten Ausgabebefehls aus dem Befehlsspeicher, um dem empfangenen Positionsfehler und den Ausgabebefehl zu summieren und die Summe an das Rückkopplungssteuerglied (2) und den Befehlsspeicher zu senden.

7. Steuereinrichtung nach Anspruch 6, **dadurch gekennzeichnet, dass** die Iterationsausführungseinrichtung (21, 22) ein Element (21) aufweist, um das Verschiebungssignal, die Veränderung des Hubprofils und den Positionsfehler zu empfangen, wobei das Element eingerichtet ist, den Iterationsprozess ein- und auszuschalten, indem der Befehlsspeicher (12) und die Elemente (8, 9, 10, 11), welche die Positionsfehler behandeln, geführt werden.

8. Steuereinrichtung nach Anspruch 7, **dadurch gekennzeichnet, dass** das Rückkopplungs-Steuerglied (2), das iterativ lernende Steuerglied (1), der Verzögerungskompensator (16) und das Ventilhubprofilelement (13) in einer Einheit ausgeführt sind, wobei die Einheit Verbindungen zwischen den Steuergliedern, dem Kompensator und dem Profilelement sowie Schnittstellen für das Ventilbetätigungssystem und den Verbrennungsmotor aufweist.

9. Steuereinrichtung nach Anspruch 7 oder 8, **dadurch gekennzeichnet, dass** die Verschiebung der Hubprofile erfolgt, wenn die Differenz zwischen einer gewünschten Kurbelwinkelposition und der tatsächlichen Position größer als 0,5 Grad ist.

10. Steuereinrichtung nach Anspruch 9, **dadurch gekennzeichnet, dass** das Rückkopplungs-Steuerglied (2) ein P-, PI-, PD-, PID- oder ein Zustandssteuerglied ist.

Revendications

1. Dispositif de contrôle d'un système de commande de valve d'échange de gaz hydro-électrolytique, ledit dispositif comprenant un contrôleur de rétroaction (2) pour actionner le système de commande de valve, **caractérisé en ce que** le dispositif comprend en outre :

    - un contrôleur d'apprentissage itératif (1) pour actionner le contrôleur de rétroaction,
    - un compensateur de délai (16) pour actionner le contrôleur d'apprentissage itératif, et
    - un élément de profil du mouvement de valve (13) pour fournir un profil de mouvement au contrôleur d'apprentissage itératif et au compensateur de délai,

    le contrôleur d'apprentissage itératif (1) comprenant :

        - une interface d'entrée (24) pour recevoir des données de mouvement de valve réelles (5) du système de commande de la valve,
        - une unité de mémoire d'erreur (9) pour enregistrer les erreurs de suivi de position de la valve,
        - une unité de mémoire d'instruction de sortie (12) pour enregistrer les instructions de sortie du contrôleur d'apprentissage itératif, et
        - un dispositif de commande d'itération (21, 14', 18', 19', 22', 23') pour mettre en route et stopper une procédure d'itération du contrôleur d'apprentissage itératif,

    le compensateur de délai (16) comprenant :

        - une seconde interface d'entrée (25) pour recevoir les données de mouvement de valve réelles,
        - une troisième interface (30) pour recevoir les données d'angle de vilebrequin (20) d'un moteur, et
        - un comparateur (17) pour comparer la paire de données de mouvement de valve réelles (5) et d'angle de vilebrequin (20) à une paire de données correspondantes du profil de mouvement, pour fournir un signal de décalage comme réponse à la comparaison, et pour transmettre le signal de décalage au contrôleur d'apprentissage itératif (1) afin d'actionner le dispositif de commande d'itération (21, 23'), laquelle procédure d'itération est conçue pour stopper le profil de mouvement en cas de décalage et pour redémarrer la procédure d'itération du profil de mouvement après la fin du décalage.

2. Dispositif de contrôle selon la revendication 1, **caractérisé en ce que** l'unité de mémoire d'instruction (12) comprend un premier élément de vecteur (41) pour enregistrer les instructions de sortie, et un premier élément de décalage (42) pour recevoir le signal de décalage et pour décaler le contenu du premier élément de vecteur en réponse au signal de décalage reçu, et l'unité de mémoire d'erreur (9) comprend les seconds éléments de vecteur (51) pour enregistrer les erreurs de pistage, et un second élément de décalage (52) pour recevoir le signal de décalage et pour décaler les contenus des seconds éléments de vecteur en réponse au signal de décalage reçu.

3. Dispositif de contrôle selon la revendication 2, **caractérisé en ce que** le profil de mouvement et lesdits premier et second éléments de vecteur sont répertoriés par les valeurs d'angle de vilebrequin ; et si la comparaison du com-

parateur (17) montre que l'angle de vilebrequin mesuré et la valeur d'angle de vilebrequin désirée avec une position de mouvement mesurée diffèrent assez, lesdits vecteurs sont décalés de telle manière que la différence diminue.

4. Dispositif de contrôle selon la revendication 3, **caractérisé en ce que** si l'erreur de pistage de position de la valve est dans un intervalle limité autour d'une valeur désirée, la procédure d'itération est interrompue, et
si l'erreur de pistage de position de la valve n'est pas incluse dans un second intervalle limité autour de la valeur désirée, la procédure d'itération recommence, et
si l'erreur de pistage de position de valve n'est pas incluse dans un troisième intervalle limité autour de la valeur désirée, la procédure d'itération est réinitialisée.

5. Dispositif de contrôle selon la revendication 4, **caractérisé en ce que** l'élément de profil de mouvement de valve (13) comprend un certain nombre de profils de mouvement, et le changement de profil de mouvement est configuré pour être exécuté à la réception d'une instruction de changement, auquel cas
la procédure d'itération est configurée pour s'arrêter quand la position de la valve indique que la valve est fermée et pour redémarrer après le cycle du système de commande de la valve.

6. Dispositif de contrôle selon la revendication 4 ou 5, **caractérisé en ce que** le contrôleur d'apprentissage itératif (1) comprend :

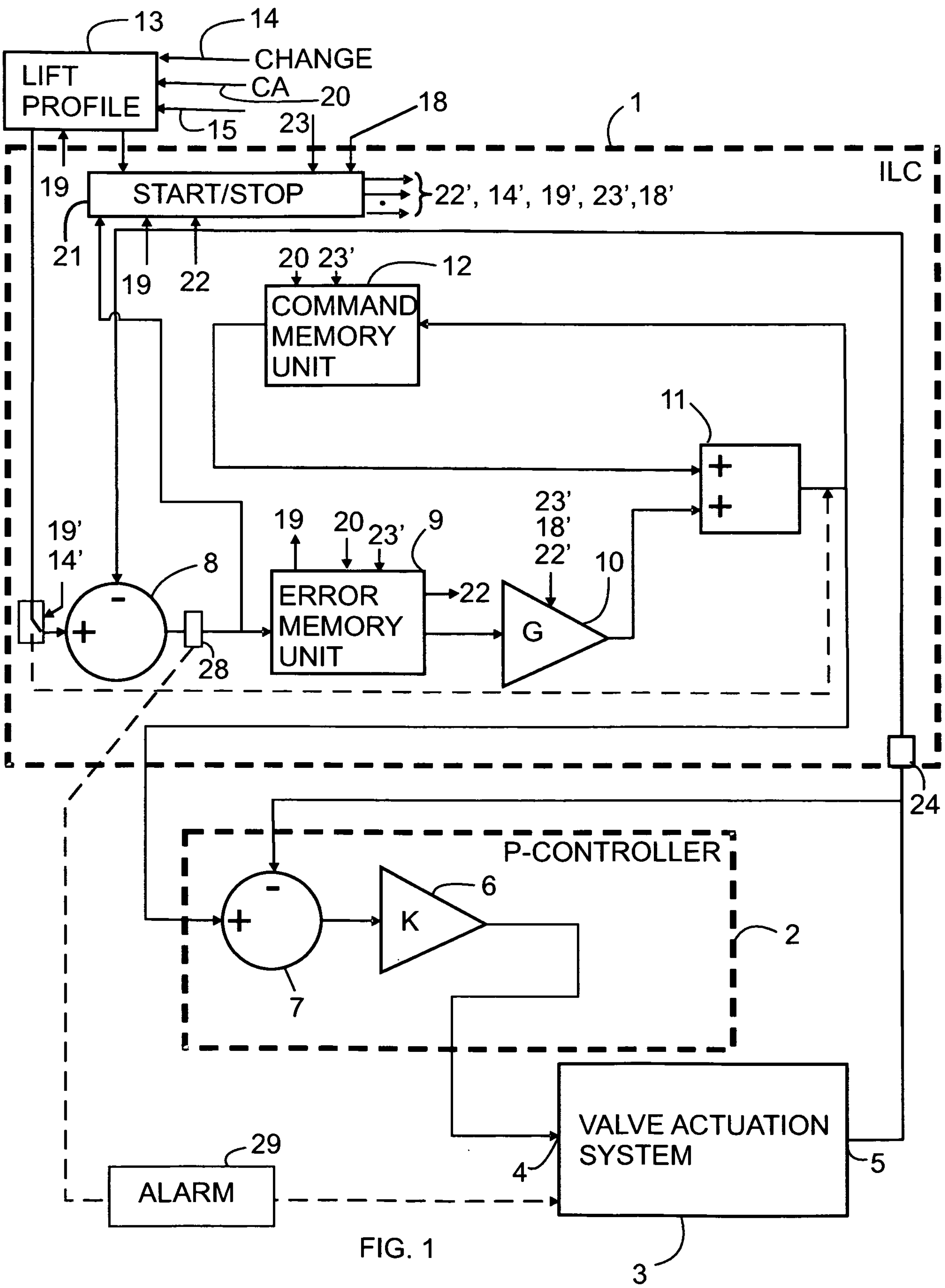
un élément calculateur d'erreur (8) pour calculer l'erreur de pistage de position de la valve à partir des données de mouvement de valve réelles et du profil de mouvement utilisé et pour transmettre l'erreur de position à la mémoire d'erreur (9), et
un élément d'amplification (10) pour recevoir l'erreur de position depuis la mémoire d'erreur, pour multiplier l'erreur de position avec un facteur d'amplification, laquelle amplification est réglable par le dispositif de commande d'itération et
un second élément d'addition (11) pour recevoir l'erreur de position multipliée et la dernière instruction de sortie depuis la mémoire d'instruction, pour additionner l'erreur de position reçue et l'instruction de sortie, et pour transmettre la somme au contrôleur de rétroaction (2) et à la mémoire d'instruction.

7. Dispositif de contrôle selon la revendication 6, **caractérisé en ce que** le dispositif de commande d'itération (21, 22) comprend un élément (21) pour recevoir le signal décalé, le changement du profil de mouvement, et l'erreur de position, lequel élément est configuré pour mettre en route et stopper la procédure d'itération en guidant la mémoire d'instruction (12) et les éléments (8, 9, 10, 11) s'occupant des erreurs de position.

8. Dispositif de contrôle selon la revendication 7, **caractérisé en ce que** le contrôleur de rétroaction (2), le contrôleur d'apprentissage itératif (1), le compensateur de délai (16), et l'élément de profil de mouvement de valve (13) sont exécutés en une entité, laquelle entité comprend des connexions entre les contrôleurs, le compensateur et l'élément de profil, et des interfaces pour le système de commande de valve et le moteur à combustion interne.

9. Dispositif de contrôle selon la revendication 7 ou 8, **caractérisé en ce que** le décalage du profil de mouvement se présente lorsque la différence entre la position d'angle de vilebrequin désirée et la position réelle est supérieure à 0,5 degré.

10. Dispositif de contrôle selon la revendication 9, **caractérisé en ce que** le contrôleur de rétroaction (2) est un contrôleur P, PI, PD, PID, ou un contrôleur d'état.



13
14
LIFT PROFILE
CHANGE
CA
20
15
23
18
1
ILC
19
START/STOP
22', 14', 19', 23',18'
21
19
22
20 23'
12
COMMAND MEMORY UNIT
11
+
+
19' 14'
19
20
23'
9
23' 18' 22'
8
10
ERROR MEMORY UNIT
22
G
28
24
P-CONTROLLER
6
K
2
7
VALVE ACTUATION SYSTEM
29
ALARM
4
5
3

FIG. 1

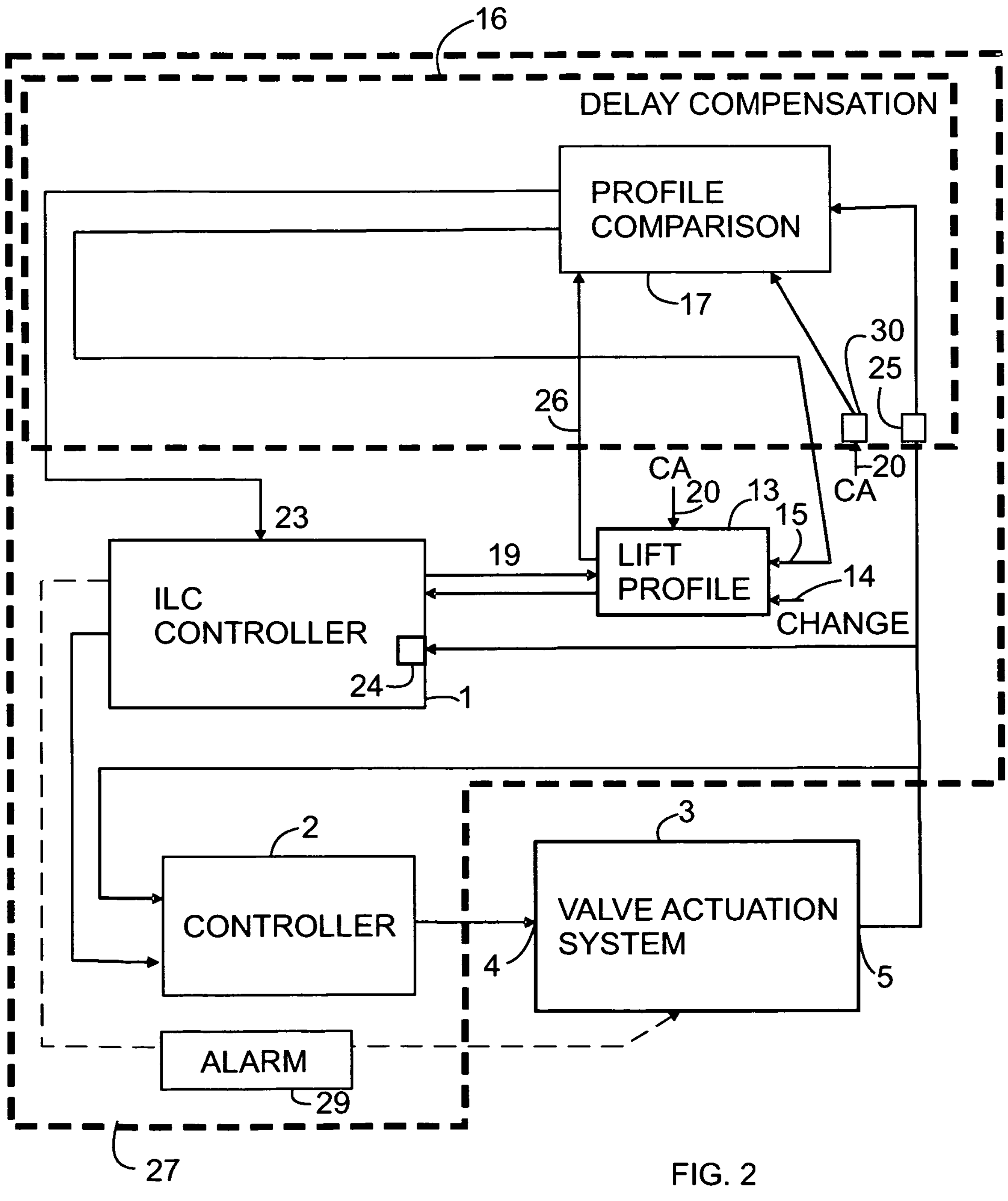

16
DELAY COMPENSATION
PROFILE
COMPARISON
17
30
25
26
CA
20
13
15
20
CA
23
LIFT
PROFILE
19
14
CHANGE
ILC
CONTROLLER
24
1
2
3
CONTROLLER
VALVE ACTUATION
SYSTEM
4
5
ALARM
29
27

FIG. 2

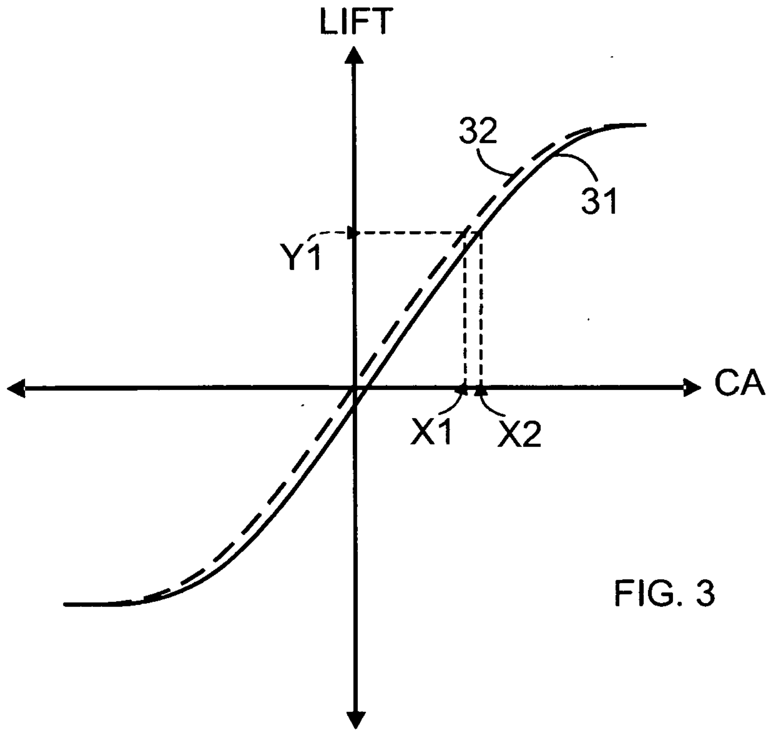


FIG. 3

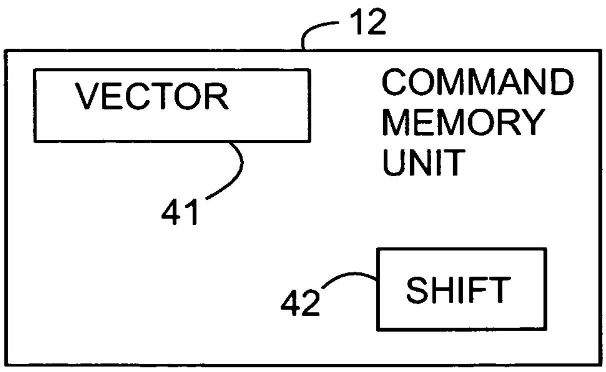


FIG. 4

FIG. 5