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(54) **System and method for estimating a model of the operation of an oil system of a vehicle engine**

(57) The invention relates to a system for estimating a model of the operation of an oil system (11) of a vehicle engine, which system (11) comprises control means for determining values representing the operation of the oil system. According to the invention, said control means (14) is adapted for monitoring at least one component controlled by the operation of said oil system and acquiring operational data for said component, wherein said control means (14) is adapted to acquire said operational data in order to provide an adaptive estimation of the operation of the oil system (11). The invention also relates to a method for estimating a model of the operation of an oil system.

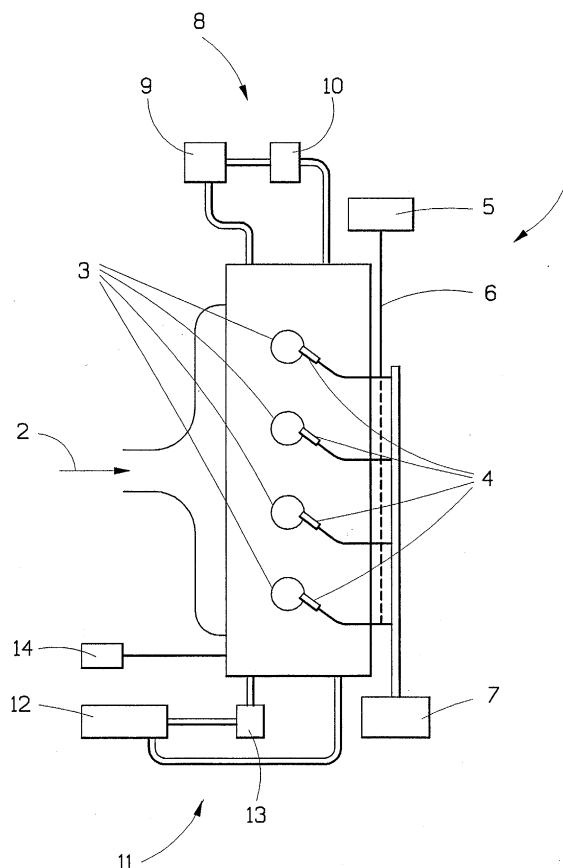


FIG.1

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Description

TECHNICAL FIELD:

[0001] The present invention relates to a system for estimating a model of the operation of an oil system of a vehicle engine, which system comprises control means for determining values representing the operation of the oil system.

[0002] The invention also relates to a method for estimating a model of the operation of an oil system of a vehicle engine, comprising the step of monitoring values representing the operation of the oil system.

BACKGROUND ART:

[0003] Vehicle engines are normally equipped with an oil distribution system which is used for lubricating and cooling various parts of the engine. In modern vehicle engines, there are also components which are controlled by measured values which indicate the operation of the oil system of the engine, e.g. arrangements for providing variable cam timing (VCT) and cam profile shifting. Such arrangements are controlled by an engine control system, which in turn receives values which represent the operation of the oil system.

[0004] During calibration of arrangements of the above-mentioned type in the engine control system, the influence from the existing oil pressure and the existing oil temperature should be compensated for. In today's engine systems, this can be achieved by using the engine coolant as a control parameter. In this regard, it can be noted that today's increasing demands on fuel mileage and driveability, and also added complexity of the engine, increase the requirements on the engine control system and thus the level of control which is necessary for correct operation of the systems involved.

[0005] During the above-mentioned calibration process, parameters which represent the operation of the oil distribution system are usually measured for one or more test engines. The measurement data thus represents the oil system performance for a particular engine of a certain engine model, with a specific oil type at a certain point in the life span of the oil and the engine. As there are many different oil qualities, and as there are manufacturing tolerances for the oil system and also for the rest of the engine, a wide span in oil system performance can be expected to occur for one and the same engine type. These differences are controlled by having a robust calibration of all systems which are depending on the oil system. Such a calibration will absorb all these differences. This affects for example the fuel consumption, the engine performance and the driving performance.

[0006] In order to improve the quality of this calibration, it can be necessary to use a calibration model using values which indicate the oil pressure in the oil distribution system. Such an oil pressure calibration model has

to take discrepancies between engines, vehicles and oil quality into account. Consequently, if the actual oil pressure in the engine could be more accurately modelled, a more accurate calibration of all the systems which are depending on the oil system could be achieved. A problem with such an approach is due to factors such as varying engine tolerances and different oil types, which means that the oil pressure can be expected to vary a lot between engines of the same type. Also, as the oil temperature changes, the oil deteriorates as time passes, the engine is subject to wear and tear as time passes and due to the fact that different oil types are used between oil changes.

[0007] Increased demands on fuel consumption and driving performance will in turn increase the demands for the calibration system. As mentioned above, the engine coolant temperature can be measured or estimated in order to be used as a control parameter. Furthermore, the patent document US 6561015 describes how the oil pressure of an engine is estimated using the engine velocity and the oil temperature as input parameters. Furthermore, the patent document US 6536390 teaches a variable valve-timing engine cooperating with an oil pressure controlling unit which is arranged for controlling a phase angle adjusting unit.

[0008] However, a problem with previously known systems is that they cannot be used for a more accurate estimation of the oil pressure in order to achieve an more accurate calibration of all the systems which are depending on the oil system.

SUMMARY OF THE INVENTION:

[0009] It is an object of the present invention to provide a system and method by means of which the above-mentioned problem can be solved, in particular for providing a highly accurate model of the operation of the oil system, as compared with today's systems, even though there are substantial discrepancies for example between different engines, vehicles and the type of oil being used in different engines.

[0010] This object is achieved by means of a system as initially mentioned, in which said control means is adapted for monitoring at least one component controlled by the operation of said oil system and acquiring operational data for said component, wherein said control means is adapted to acquire said operational data in order to provide an adaptive estimation of the operation of the oil system.

[0011] This object is achieved by means of a method as initially mentioned, which comprises monitoring at least one component driven depending on the operation of the oil system, acquiring operational data for said component, and using the operational data and the estimated performance of the oil system in order to provide an adaptive estimation of the operation of the oil system.

[0012] According to the present invention, any control

system driven by the oil system can be used to adapt the oil pressure model. Any differences in the performance of the specific system will give information that can be correlated to an oil pressure deviation from an estimated value. This information is sent back to the model, thus adapting it over the life of the engine. Consequently, the actual oil pressure is modelled by the engine control system depending on changes for example due to wear or different oil type being used, and can be adapted to any individual engine.

[0013] Examples of advantages that are obtained by means of the present invention are:

- A more stable calibration is acquired, and thus the efficiency of the engine is increased as the calibrated components are used at their full potential.
- The robustness is increased, since an automatic adjustment of the calibration according to the specific engine performance can be done.
- An additional advantage is to use the adaptation data as a diagnostic tool for the engine. Engine problems can be correlated to poor oil system performance. The impact of different oil qualities can also be evaluated on the field.

[0014] Preferred embodiments are disclosed in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0015] The present invention will now be described more in detail with reference to the appended drawings, where

Figure 1 schematically shows an engine system for a vehicle; and

Figure 2 shows a flow chart explaining the operation of the present invention.

PREFERRED EMBODIMENT:

[0016] In Figure 1, a schematic view of a arrangement comprising a combustion engine 1 of a vehicle is indicated. The invention may be applied to many kinds of combustion engines. However, according to the preferred embodiment, the invention will be explained with reference to a direct injection petrol engine. The engine 1 is fed with incoming air via an air inlet 2. The engine 1 is further provided with a number of cylinders 3 and a corresponding number of injecting devices in the form of electrically controlled injectors 4 for injection of fuel into each individual cylinder 3. Even though Figure 1 shows an embodiment having four cylinders 3, the invention is not limited to such a number of cylinders but can be implemented with engine having another number of cylinder.

[0017] Each injector 4 is connected to a central engine control unit 5 through an electrical connection 6. The control unit 5 is preferably computer based and arranged to control, in a known manner, the fuel supply to each individual injector 4, using fuel from a fuel tank 7 so that, in each instant, an appropriately adapted air/fuel mixture is fed to the engine 1. The engine 1 is also provided with a coolant system 8 for cooling the engine 1, which system comprises a coolant fluid container 9 and a coolant pump 10. The coolant fluid is circulated in the coolant system 8 by means of the pump 10.

[0018] The engine 1 according to the embodiment is designed with an oil distribution system 11 for lubricating and cooling various parts of the engine 1 in a previously known manner. To this end, the oil is kept in a container 12 and fed into the engine 1 by means of a oil pump 13. The oil acquires a certain oil pressure due to the oil temperature, the oil viscosity and the flow rate of the oil pump 13. In modern vehicle engines, there are also many components which are controlled by the operation of the oil system of the engine, e.g. arrangements for providing variable cam timing (VCT) and cam profile shifting. Such arrangements are previously known per se, and for this reason they are not described in detail here. However, it can be noted that the operation of such arrangements is dependent on the oil pressure and/or the oil temperature. In order to acquire an adequate operation, it is beneficial to determine the state of operation of the oil system 11. In this manner, the oil pressure and/or the oil temperature can be determined as accurately as possible.

[0019] When oil system dependent components are calibrated, the operational status of the oil system is measured for one or more individual test engines of a certain engine model. It is previously known that such measurement data describe the operation of the oil system for a certain engine of a certain engine model with a particular oil type at a certain point in the life span of the oil and the engine. In this manner, a first oil pressure model can be said to be defined. Such a first, basic, oil pressure model can be said to be nominal. This nominal model can be regarded as a rough estimate which is based on a specific test engine operated at certain conditions. In particular, the test engine is used in an engine test rig where the environment is closely controlled and the specification of the engine in question is well known.

[0020] However, the present invention relies on the insight that oil pressure between different engines can be expected to vary. The invention consequently provides a solution in which a value of the estimated oil pressure in fact can be used as an input to an engine control system by adapting said value. In this manner, it can be used in connection with any given engine and for controlling any system which depends on the operation of the oil system.

[0021] According to the invention, this first nominal oil pressure model uses the oil temperature, the oil viscosity and the speed of the oil pump as measured param-

eters for estimating a value representing the oil pressure. The measured parameters are fed into a oil system control unit 14 in order to calibrate the components which are dependent of the oil system. The oil system control unit 14 is equipped with a computer memory and calculation functions in a known manner. In this regard, it can be noted that the oil viscosity is a function of the oil temperature, whereas the oil pump velocity is a function of the engine speed. Also, the oil pressure is a function of the oil viscosity and the oil pump velocity.

[0022] Furthermore, even though the oil system control unit 14 and the central engine control unit 5 have been indicated as two separate units in Figure 1, it can be noted that these two units can alternatively be implemented as modules in one single control unit.

[0023] The oil temperature in the engine 1 can either be measured with an oil temperature sensor (not shown) or modelled using several engine parameters such as engine speed, coolant temperature and engine load.

[0024] The oil viscosity depends on the oil quality that is used in the test engine, and is therefore known.

[0025] The speed of the oil pump is 13 measured as revolutions per minute and is measured with a suitable sensor (not shown).

[0026] These data are used to acquire a first nominal oil system model, from which an estimated oil pressure value may be derived, as the oil system control unit 14 is fed with measurements or computations of estimates of the oil temperature and measurements of the speed of the oil pump 14. As there are many different oil qualities, and as there are manufacturing tolerances for the oil system 11 and also for the rest of an engine 1 of a specific type, a wide span in the operation of the oil system occurs for the engines that belong to this engine type. For this reason, the first, nominal oil pressure model is further improved and made more accurate by means of a second oil system model, which is adaptive. By means of this second model, the oil pressure may be determined more accurately for each individual engine. The present invention thus relies on the principle that the nominal model is supplemented with a second adaptive model.

[0027] The principle behind the invention will now be described more in detail. One of the components which is controlled by the oil system, in this example an arrangement (not shown) for providing VCT (Variable Cam Timing), is monitored during the test engine run, which test engine run is basically described above. The operation of the VCT is monitored at the same time as the parameters for the first nominal oil pressure model are monitored. The VCT performance may be measured as a function of the engine speed, oil pressure and oil temperature. As the first oil pressure model is true for the individual test engine used at the test, the monitored performance parameters of the VCT is stored in the oil system control unit 14.

[0028] Should, for another individual engine, the monitored VCT arrangement performance differ from the

stored VCT performance parameters, which is most probable, this difference is related to a certain discrepancy in the first oil pressure model. The first oil pressure model in combination with the monitoring of the VCT performance and the adaptive change of the first oil pressure model in correlation with possible differences from the stored VCT parameter value constitute a second adaptive oil pressure model. The second adaptive oil pressure model thus comprises the first oil pressure model and the adaptation that is made possible by the monitoring of the VCT arrangement. The second adaptive model can be used in the engine control unit 5 for controlling for example the VCT arrangement.

[0029] Should a difference from the stored values representing the VCT arrangement be detected, the second adaptive oil pressure model provides a new value for the oil pressure by adapting the first oil pressure model. The oil pressure is not corrected, only identified. All the components that are dependent on the oil pressure, e.g. the arrangements for VCT or cam profile shifting, are compensated for by means of the new oil pressure. As long as the VCT performance difference is constant, the same adaptation is used on the first oil pressure model. Should a new difference occur in the VCT performance, a new adaptation is calculated.

[0030] Below, an example will be described with reference to the flow chart in Figure 2.

[0031] During the running of a test engine of a certain engine model 15, values representing the oil system performance or operation for the test engine is measured and stored 16, being a base for a first oil pressure model. The performance of the VCT arrangement of the test engine is also measured and stored 17. A consumer engine (i.e. an engine intended for mounting in a manufactured vehicle, as opposed to a test engine) is installed in a vehicle, and the oil system parameters and the VCT performance parameters of the test engine are fed into the oil system control unit 18 of the consumer engine. During operation of the consumer engine, the VCT performance of the consumer engine is monitored 19, and is compared with the stored VCT performance 20. It will probably differ from the stored VCT performance of the test engine. This is due to manufacture tolerances between oil systems and engines of the same kind, and may also be due to the fact that another oil with another viscosity is used. The second adaptive oil pressure model then compensates for these differences 21, and provides the correct oil pressure value 22.

[0032] All the components that are dependent on the oil pressure, e.g. the VCT or cam profile shifting arrangements, are then compensated for the calculated oil pressure 23. Should the monitored VCT performance correspond to the stored one 20, it also corresponds to the VCT performance of the test engine. In that case, the first oil pressure model that is valid for the test engine, also is valid here, and no adaptation of the first model has to be performed, and the oil pressure may be calculated directly without adaptation 22.

[0033] The VCT performance is repeatedly monitored 20. The present adaptation is valid as long as the monitored VCT performance has the same correlation to the stored VCT performance. Should the correlation change, the adaptation is changed 21.

[0034] As the oil in the new engine ages, its viscosity changes and thus the oil pressure also changes. This is detected, as the VCT performance changes 20, and thus the second adaptive oil pressure model provides a new oil pressure value 21, 22 that may be compensated for 23. The same thing happens when the oil system and the engine age, and wear and tear changes their performance and thus the oil pressure.

[0035] The second adaptive oil pressure model more or less continuously monitors changes of the VCT operation, and thus of the oil pressure. It is beneficial to isolate a certain repeatable moment of the VCT operation which is executed several times during a drive cycle, as the VCT operation may change due to the way the driver acts, and not due to the fact that the second adaptive oil pressure model needs to adapt to a change. One possible such moment is the cleaning cycle of the VCT, since it then makes a sweep from the current position to an end position and back.

[0036] To acquire a more stable judgement, the measurements resulting from the adaptation are preferably low pass filtered.

[0037] The invention will not be limited to the embodiment discussed above, but can be varied within the scope of the appended claims. For example, the invention is not limited to engines if the direct injected type, but can also be used with other types of engines, such as conventional petrol engines and diesel engines, that is, various types of fuel-powered engines having an oil system and components which are controlled by the oil system and need to be calibrated depending on the oil pressure.

[0038] Although the description above is focused on the use of VCT arrangements, any system which is controlled by the oil system may be used for identifying the need for adaptation and the adaptation value.

[0039] It is also assumed that the adaptation according to the invention is performed on the oil pressure model. It is of course possible to adapt an oil temperature model instead. The invention may, in other words, also be applied on an oil temperature model and viscosity model.

Claims

1. System for estimating a model of the operation of an oil system (11) of a vehicle engine, which system (11) comprises control means (14) for determining values representing the operation of the oil system, **characterized in that** said control means (14) is adapted for monitoring at least one component controlled by the operation of said oil system and ac-

quiring operational data for said component, wherein said control means (14) is adapted to acquire said operational data in order to provide an adaptive estimation of the operation of the oil system (11).

2. System according to claim 1, **characterized in that** said values representing the operation of the oil system (11) comprises values representing the pressure of oil in said oil system (11).
3. System according to claim 1 or 2, **characterized in that** said values representing the operation of the oil system (11) comprises values representing the temperature of oil in said oil system (11).
4. System according to any of the preceding claims, **characterized in that** the component that is controlled by the operation of the oil system (11) is an arrangement for variable cam timing.
5. System according to any of the preceding claims, **characterized in that** the component that is controlled by the operation of the oil system (11) is an arrangement for cam profile shifting.
6. Method for estimating a model of the operation of an oil system (11) of a vehicle engine (1), comprising the step of:

monitoring values representing the operation of the oil system (11);

characterized in that the method further comprises:

monitoring at least one component driven depending on the operation of the oil system (11); acquiring operational data for said component, and using the operational data and the estimated performance of the oil system (11) in order to provide an adaptive estimation of the operation of the oil system (11).

7. Method according to claim 6, **characterized in that** it comprises measuring the oil pressure in said oil system (11).
8. Method according to claim 6 or 7, **characterized in that** it comprises measuring the oil temperature in said oil system (11).
9. Method according to any of the claims 6-8, **characterized in that** measured values during the adaptively estimated operation of the oil system (11) are low-pass filtered.
10. Method according to any of the claims 6-9, **characterized in that**

terized in that the adaptively estimated operation of the oil system (11) is used for calibration of at least one component that is controlled by the oil system (11).

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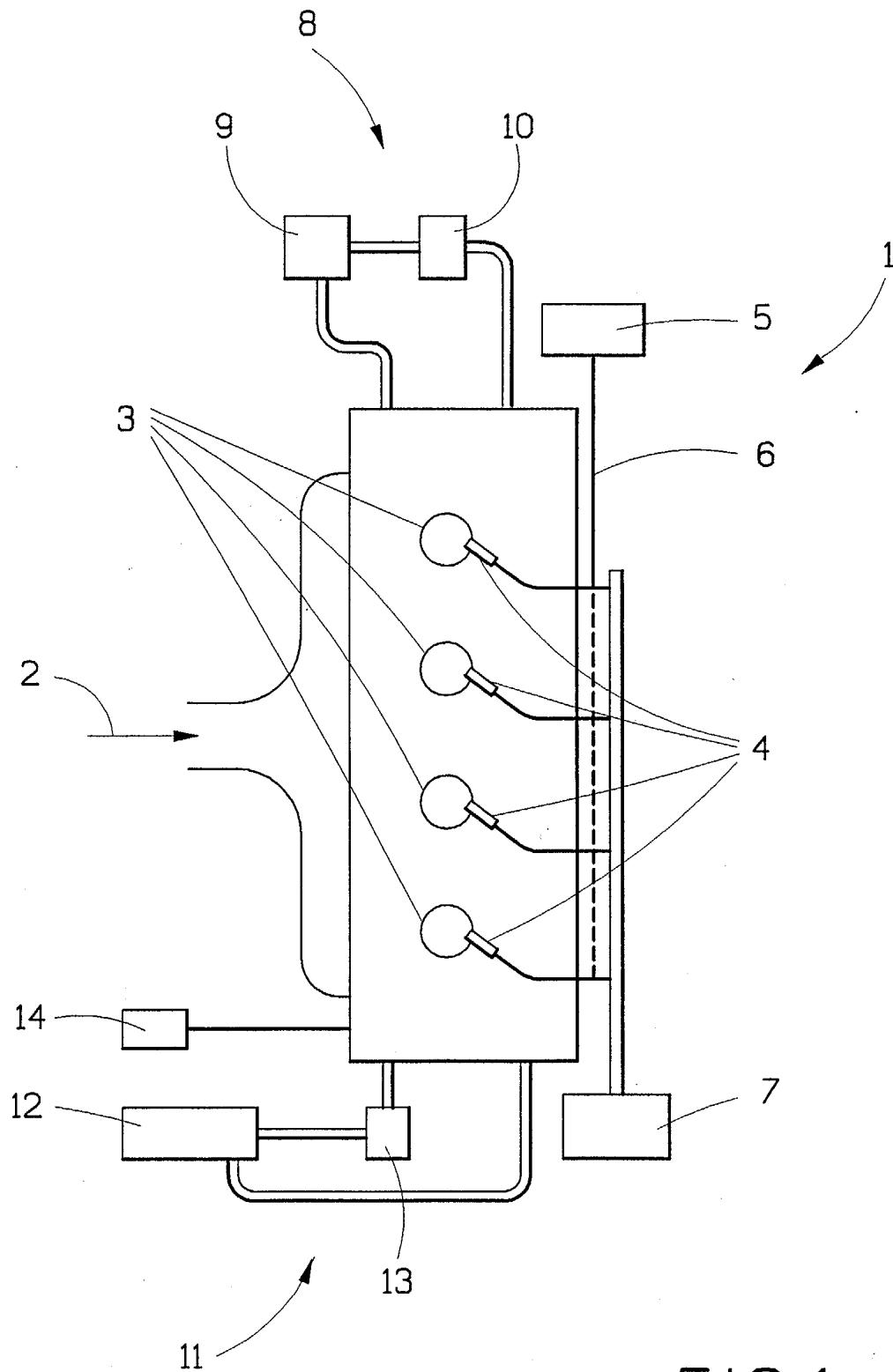
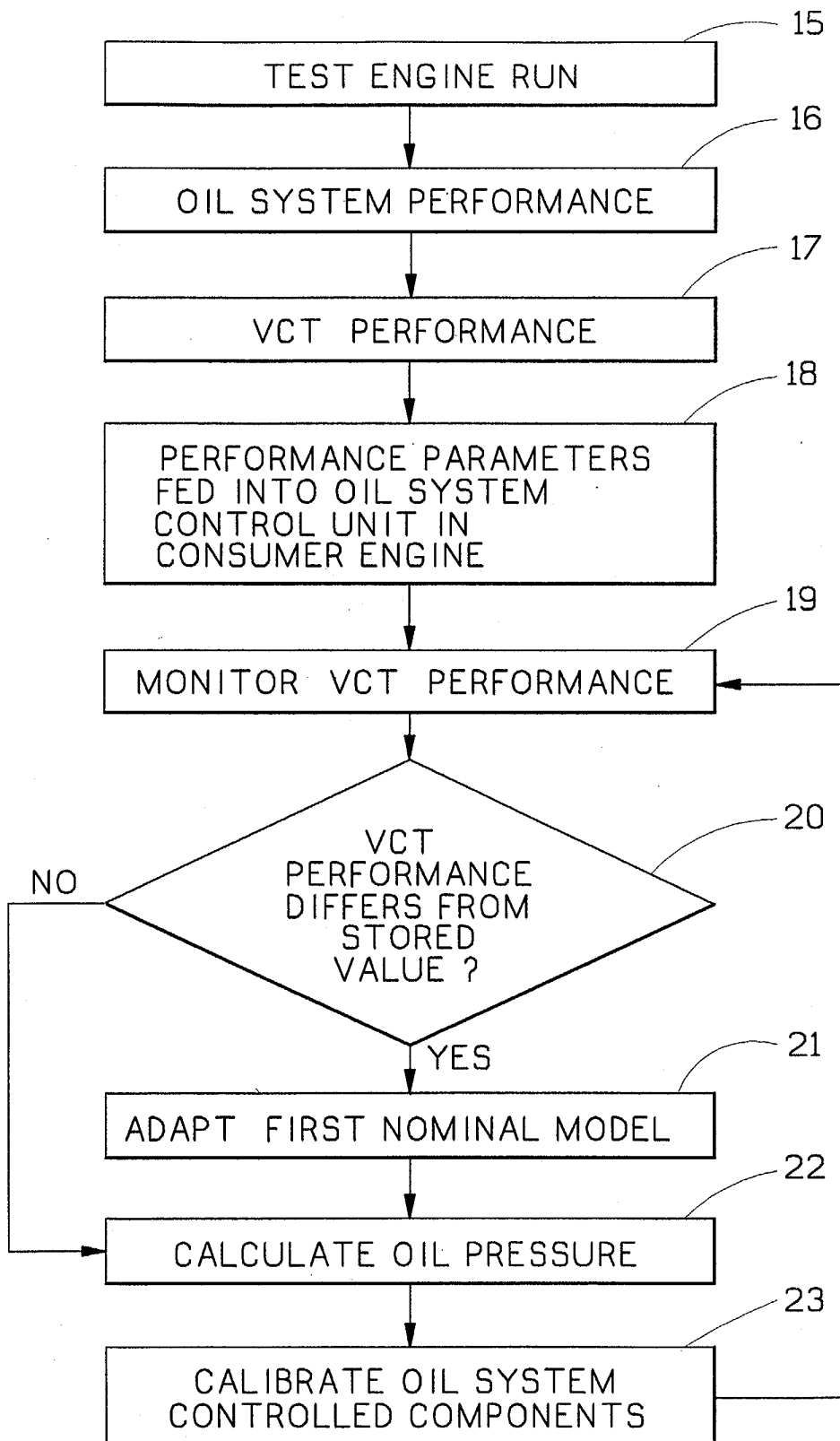


FIG.1

FIG.2



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 04 00 0091

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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A	----- US 5 646 341 A (SCHRICKER DAVID R ET AL) 8 July 1997 (1997-07-08) * claims 1,2,7,10 *	1,6	
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The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
Munich		14 June 2004	Clot, P
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (F04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 04 00 0091

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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