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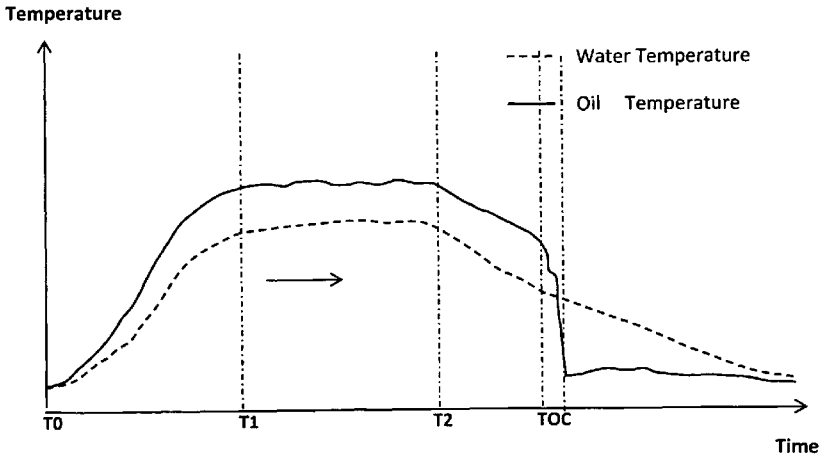
(54) Title: OIL CHANGE DETECTING METHOD

FIG. 2



(57) Abstract: A method and system for detecting the change of engine oil of a vehicle. An unexpected fast drop of the oil temperature at the Time of Oil Change (TOC) interval is considered as an indication that there has been a change of oil. The reliability of the method is considered to be rather high since the oil shall be changed while it is hot in order to be faster and better drained from the oil system and fresh oil normally is at room temperature. The oil temperature may be monitored over a long time or there may be only a few strategically choosen oil temperature determinations. The oil temperature limit or temperature change limit may be predefined by using tables and/or reference curves of the oil temperature cooling. Temperatures of a reference, e.g water in a cooling system can be used, in order to correlate for influences from ambient conditions.

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Oil change detecting method

TECHNICAL FIELD OF THE INVENTION

The invention relates to a method and a system for detecting the change of engine oil of a vehicle, e.g. a truck.

BACKGROUND OF THE INVENTION

In order to prolong the life time and maintain the performance of a vehicle, the vehicle shall be serviced at regularly intervals. An important feature at these services is the change of engine oil. The change of oil is one of the most important factors for maintaining the functionality of the engine and prolonging the life time of the engine.

It is thus desired to be able to follow up whether or not there has been a change of engine oil within the stipulated time interval, otherwise a change of oil shall be performed. However, it is also desirable to avoid a shift of oil if there has been a change of oil recently in order to save costs.

A change of engine oil is generally logged in the log book of the vehicle in order to perform the oil changes at the right times. However, there is a chance that a change of oil not is entered in the log book such that an unnecessary change of oil is made. This situation is of no harm for the vehicle or engine but will induce an unnecessary additional cost. It is worse if a scheduled change of oil entered into the log book never occurs, e.g. if a notification is made before the change

actually is made and the oil change is cancelled without correcting the notification in the log book. The omitted oil change may be of harm to the engine and the engine may perform worse considering the torque delivered, fuel economy and harmful substances in the exhaust gases.

In order to keep track of oil changes, different systems and methods have been suggested. It has been suggested in EP 1 396 616 to measure the viscosity properties of the oil in order to decide if a change of oil shall be made. The viscosity is measured by a rising time of a heated portion of the oil contained in container dedicated for this purpose. However, this system implies that a rather complex system is built up in order to estimate the viscosity of the oil and keep a control of the oil changes.

In US 6,484,127 is described a method and a system in which engine oil pressure is measured during start-up of an engine and changes in time to reach a certain pressure is used to indicate there has been a change of a filter. However, even though filter and oil are generally changed at the same time, it is not necessarily the case. This system will thus not directly indicate that there has actually been a change of oil but only an indication that a change of oil has been performed based on the recording of a change of filter.

Oil level could also be used for detecting a change of oil. However, a change of oil level may also occur due

to leakage or a refill of oil without actually make a change of oil and is thus an unsure indication.

Hence, there is a desire for an uncomplicated method and system which in an easy way may log the change of oil.

DESCRIPTION OF THE INVENTION

The invention relates to a method and a system for detecting a change of engine oil of a vehicle. The method is based on using a change of temperature, or temperature drop, of the engine oil temperature which will occur when the used oil is changed or replaced with fresh oil as an oil change indication. Hence, by determining the temperature of the oil and using a decrease of the oil temperature deviating from a reference value or reference graph based on an expected decrease of the oil temperature, will it be possible to get an indication there has been a change of oil.

The oil temperature may be determined directly by measuring the engine oil temperature or indirectly by measuring another parameter of the oil indicative of the oil temperature or a temperature of another part of the engine or vehicle which may be correlated to the engine oil temperature. The basis for the assumption that a temperature drop may be used as an indication of a change of oil is that the engine oil shall be changed while it is warm in order to allow the used oil to better flow out of the engine oil system. The engine oil temperature is normally well above 50, typically between 60 - 90 degrees Celsius when it is replaced with fresh oil normally stored at room temperature,

e.g. around 20 - 25 degrees. Hence, there is normally a rather large difference between the temperature of the oil contained in the engine oil system and the temperature of the fresh oil to be entered into the system. Due to the fact that the temperature difference is expected to be rather large, methods based on rather rough estimations may function with a desired accuracy in most cases. The method may thus be realized by a number of different ways for estimating the reference values or reference graphs of the engine oil temperature and different methods for deciding a criterion or criteria to be fulfilled for the oil temperature or oil temperature change rate in order to be used as an indication that there has been a change of oil. The criteria is based on at least one determined oil temperature indicating a temperature below a limit temperature or a quicker change rate of the temperature than a temperature change rate limit.

The time points for performing oil temperature determinations may also vary as well as the number of temperature measurements to be used for deciding whether or not there is an indication of a change of engine oil. The determination of the oil temperature may be triggered by the turning off and/or the turning on of the engine but they could also be performed continuously regardless of the status of the engine even though the change of engine oil not is likely, or even possible, to be performed when the engine is running.

An advantage by using the temperature of the engine oil as an indication of the change or replacement of the

engine oil is that a temperature sensor for measuring the engine oil temperature is present in essentially all vehicles today and there is in general no need for adding an additional sensor to the vehicle. Hence, the use of an existing oil temperature sensor provides an easy way to get a reliable determination of the oil temperature. In addition, many vehicles are also provided with some kind of vehicle computer which may be programmed to log and compare temperature values of the engine oil temperature. The determined temperature values may be used to compare with some kind of reference value or temperature limit stored in or calculated by the vehicle computer in order to decide if there is an indication that there has been a change of oil based on the engine oil temperature.

In addition to determine the engine oil temperature, further inputs may be used for making the comparative analysis, e.g. may the temperature of a cooling liquid, an engine block, parts of the exhaust gas treatment system and/or the ambient temperature be used. At least some of these parameters are commonly measured on vehicles of today thereby avoiding additional measurement equipment to be mounted to the vehicle. The use of such a reference value will make it possible to compensate for extreme temperatures of the environment which may affect the oil temperature and oil temperature change rate.

Above it has been mainly focused on using a temperature value of the engine oil as a reference or limit value for indicating a change of oil. However, it is obvious for the skilled person in the art that also the change

of the oil temperature could be used. Instead of using the temperature values explicit they could be used implicit by calculating the cooling rate of the oil temperature and faster cooling rate of the oil than a reference or limit value based on an expected cooling rate could be used for indicating there has been a change of oil. The reasoning herein will also in the following be mainly focused on using an explicit temperature limit even if the measured and estimated reference temperatures may be used implicit by estimating or calculating cooling rates.

The method for detecting a change of engine oil of a vehicle by using the temperature as a reference for oil change indication may be described to include the following steps:

- determining the oil temperature (T_{oil}) at at least one time point
- defining a temperature limit (T_{limit})
- using the defined temperature limit (T_{limit}) to compare with the determined oil temperature (T_{oil}) whereby a determined oil temperature (T_{oil}) below the defined temperature limit (T_{limit}) is considered as an indication that there has been a change of oil.

As discussed previously, the system will provide a large number of possibilities in how the above parameters are set. It could be possible to get an indication that there has been a change of oil from a single determination of the oil temperature, e.g. by measuring the oil temperature by a temperature sensor. For example, an expected temperature of the oil

temperature may be estimated from vehicle data such as cooling liquid temperature, ambient temperature and/or time and mode of engine operation. Such an estimated oil temperature could be made when the engine is turned off. This temperature could be used as a starting value in a graph, table or algorithm for estimating the cooling down sequence of the engine oil temperature. The estimation of the cooling down sequence could of course also be dependent on the ambient temperature. The temperature limit (T_{limit}) may in this case be a fixed value, e.g. somewhere between 30 and 50 degrees Celsius, or depending on other factors. However, when it is estimated that the oil temperature should have reached the temperature limit (T_{limit}), or rather a temperature slightly above, the actual oil temperature is determined. If the determined oil temperature (T_{oil}) is below the defined temperature limit (T_{limit}) when a comparative analysis is made, it is considered there is an indication that there has been a change of oil.

As an alternative, or as a complement, the expected cooling of the engine oil versus time during the stop of the engine may be retrieved from a graph, algorithm or table in order to get a reference temperature wherefrom limit temperatures for different time points are set. A temperature measurement may be made or recorded when the engine is turned on again. A temperature limit, taking into account the time period from the estimated oil temperature at engine turn off to the measured engine oil temperature at engine turn on, is decided based on an engine oil cooling temperature table, an algorithm or graph. If the

measured temperature is below the temperature limit, it is indicated that a change of oil has been made.

Hence, the above methods, i.e. to perform an oil temperature determination after a certain time period has elapsed and/or at a predefined expected, estimated oil temperature if no oil change should have been and include the feature of performing an oil temperature determination when restarting the engine, may complement each other and be incorporated in the same control system. If the vehicle not should be restarted for a long time, e.g. oil is changed while the vehicle will be at rest overnight, the possible time limit for providing a relevant oil temperature determination may have passed when the vehicle is started. In case the oil change control system only measures the oil temperature when the vehicle is restarted is it thus possible there not will be any indication that a change of oil has been made if the time interval between the vehicle engine is turned off and it is restarted is too long. However, if there also is included a function for the determination of the oil temperature triggered either by

- the time estimated to reach a set oil temperature limit T_{limit}, based on an expected oil temperature as if the oil not is changed or
- perform an oil temperature determination at a specific time point after the engine is shut off for which an oil temperature limit T_{limit}, based on an expected oil temperature as if the oil not is changed, is set.

Hence, by using the above described control system for performing oil temperature determination, it will be

indicated that a change of oil has been made provided the criteria is fulfilled, i.e. the oil was changed for fresh oil before the determination was triggered and the fresh oil was cold enough to be below the temperature limit T_{limit} and a change of oil will be indicated even if the engine not is restarted for a long time.

On the other hand, if the oil change is made quickly, the temperature determination based on reaching a predefined, fixed temperature limit T_{limit} at a certain time point will not be performed if the engine is started before it is estimated the temperature limit should have been reached. The oil temperature will start to rise again as the engine start to work. However, according to the above described control system, a start of the engine will trigger a determination of the oil temperature. Provided the fresh oil is cold enough, i.e. below the relevant temperature limit T_{limit}, there will be an indication that a change of oil has been made.

In case both these methods are used, there could be some kind of system for controlling those two positive indications for change of oil being within a certain time interval should only indicate one change of oil. However, if the indications of oil changes is logged automatically with time points for the detected indications, it is quite obvious that indications within the same hours or same day probably indicates one and same change of oil. Furthermore, the most relevant information from the log book is in general to keep track of the last change of oil. The total number

of oil changes over the life time, without the relevant time points, is in general of minor interest.

Hence, it is possible to use the method as described above for indicating a change of oil from one single determination of the oil temperature. There is thus a possibility to perform the method without the need of performing and storing a multitude of temperature measurements or determinations of the engine oil temperature.

However, in order to improve the accuracy of the method and reliability of the indication that there has been a change of oil, it is generally considered to be of an advantage to perform several determinations or measurements of the engine oil temperature. For example, if there is a quick change of oil made immediately when the engine is shut down and the oil temperature determination is made quite a long time after the oil change is made, the new oil may be heated by the hot engine and other hot parts in contact with the oil such that the temperature difference not clearly indicate that a change of oil has occurred. Hence, if the oil change control system is programmed to perform several determinations of the actual oil temperature after the engine is turned off and compare these oil temperature determinations with temperature limits T_{limit} based either on a reference value, reference curve and/or previous, recent oil temperature determinations, may a change of oil more reliably be detected. A series of oil temperature determinations may be made for example every 30 seconds or every 5 minutes from the moment the engine is turned off and

compared with temperature limits T_{limit} which is specific for each oil temperature determination. In the case several oil temperature determinations are made is it of course obvious that the same methods as described previously may be used for determining the oil temperature and/or predicting an estimated oil temperature as if no oil change has occurred.

Worth to be noted, the temperature limit (T_{limit}) (or temperature change rate limit (delta T_{limit})) may still be predefined before any measurements of the oil temperature has been made or stored, e.g. T_{limit} may be based on tables or graphs representing expected temperatures ($T_{expected}$) of the engine oil versus time during cooling down of the engine oil when the engine is turned off. It could also for example be possible to use different sets of tables or graphs for the expected cooling down of the engine oil versus time depending on the ambient temperature. Still another possibility is to use a table or graph of the temperature of another part or system of the vehicle which is heated by the work of the engine, e.g. the cooling liquid, and use the cooling down characteristics of the selected part for estimating the temperature of the engine oil at different time points during cooling down of the oil after the engine has been shut off. The limit temperature based on these expected temperatures should preferably be set to a somewhat lower temperature than the expected temperature such that a small deviation from the expected temperature due to some unforeseen influence not will cause a wrong indication of change of engine oil.

According to an embodiment of the invention comprises the method the features of

- determining the temperature T_{oil} of the oil at at least a first time point t_1 and a second time point t_2 to get the oil temperatures T_1 respectively T_2,
- using the determined temperature T_1 at the first time point t_1 for defining a temperature limit T_{limit}
- using the defined temperature T_{limit} for comparing with the second determined oil temperature (T_2) at the second time point t_2 and if the determined oil temperature value T_2 is lower than the temperature limit T_{limit}, it is considered as an indication that there has been a change of oil.

By performing several determinations of the actual oil temperature, e.g. by measuring the oil temperature, at several time points may improve the accuracy significantly. Since the time intervals between the oil temperature determinations may be reduced, a more recent and reliable value of the engine oil temperature may be used for setting the temperature limit T_{limit} for the next determined oil temperature. The temperature limit T_{limit} may for example be set to a first measured oil temperature T_1 minus a constant C, i.e. $T_{limit} = T_1 - C$.

The constant C may be also be dependent on the settings, i.e. be a semi constant or semi variable which is dependent on other parameters set by the system, e.g. time interval between the oil temperature

determinations. The constant C could also be substituted for a variable V which may be dependent on ambient temperature and/or temperature difference between ambient temperature and the oil temperature. The variable V could also be dependent on the cooling rate of the engine oil and/or another part of the vehicle, e.g. the cooling liquid, which is cooled when the engine is turned off.

The above described embodiment may for example work such that for every temperature determination made is a new T_1 and a new T_2 defined, e.g. the latest made temperature measurement is used as T_2 and the second last temperature measurement is used as T_1. When a new temperature determination is made will it be "new" T_2 the "old" T_2 will become "new" T_1. A new limit temperature T_{limit} may be set by using "new" T_1 minus a constant C or variable V, e.g. the constant may be 3 or 5 degrees Celsius if there are temperature determinations or measurements of the actual oil temperature made every minute and/or to 10 degrees Celsius lower than a temperature measurement performed 5 minutes ago.

The exact values to be used and the relevant interval for making the temperature measurements depends on the specific vehicle and engine used as well as the location of the engine oil temperature sensor. If the sensor is located in a part of the engine oil system where the oil volume is rather small and the oil is surrounded by a rather large volume of heated material, fresh oil might be heated rapidly such that the lowering of the oil temperature not will be so

significant. In this case it may be needed to make the temperature measurements with rather short intervals. In this case it may even happen that the oil temperature first will decrease rapidly and thereafter rise slowly while the oil is heated by the surrounding, hot material. Another possible scenario is that the oil temperature sensor is located at a place where the ambient conditions, e.g. wind and ambient temperature, may influence the oil temperature. In this case may the lowering of the temperature be rather quick, in particular if the engine is stopped when the vehicle is located outside in a cold and windy condition and the temperature drop of the oil could be rather quick reminding of the temperature drop occurring when there is a change of oil. In order to avoid mixing the above described situations with an actual change of oil it is desired to perform the temperature measurements of the oil at rather short intervals, e.g. at least every 5 minutes or even better every minute or more frequent. Another way of avoiding a false indication of a change of oil is to use or locate a temperature sensor which is located in a part of the engine oil system where the oil volume is rather large compared to the volume or mass of the surrounding material, e.g. an oil sump. In order to compensate for or adapt the oil change indication system to the ambient conditions, e.g. outdoor temperature and wind, may the ambient temperature be considered when making the oil temperature limit or oil temperature change limit. Another way of making corrections for the ambient temperature is to measure the cooling of another system or part of the vehicle to be used as a reference, e.g. the temperature of the cooling liquid. If the cooling

of the cooling liquid is quicker than normal, a correction of the estimated cooling rate of oil temperature is made.

Above it has been discussed that a cold and windy environment may cause a cooling of the engine oil to remind of a change of oil. On the contrary, the change of oil in a very hot outdoor climate, where the fresh oil to be changed may be contained in a reservoir which may have been heated by the ambient temperature, may cause that an actual change of oil not will cause a sufficient temperature difference to be considered as an indication of a change of oil.

The reasoning above concerning determination of oil temperatures, time intervals between the determinations and other relevant parameters which may be considered has been mainly exemplified for using an oil temperature to be compared to a temperature limit in order to get an indication that there has been a change of oil. The reasoning concerning accuracy of measurements of the oil temperature and time intervals is valid also when using an oil temperature change rate and a temperature change limit for deciding if there is an indication that there has been a change of oil which will be discussed here below.

The method for detecting a change of engine oil of a vehicle by using the temperature change rate as a reference for oil change indication may be described to include the following steps:

- determining the oil temperature (T_{oil})at at least one time point

- defining a temperature change rate limit (delta T_{limit}) of the oil temperature (T_{oil})
- using the temperature change rate limit (delta T_{limit}) to compare with an oil temperature change rate (delta T_{oil}) based on the determined oil temperature (T_{oil}), whereby an oil temperature change rate (delta T_{oil}) indicating a quicker cooling rate of the oil temperature (T_{oil}) than the temperature change rate limit (delta T_{limit}), is considered as an indication that there has been a change of oil.

In order to decide an oil temperature change rate (delta T_{oil}) there must be at least two temperatures used. A first value of the oil temperature change rate (delta T_{oil}) could be made by the use of an estimated temperature, e.g. as suggested earlier when discussing the estimation of a temperature when turning off the engine, and a determined oil temperature (T_{oil}) at a time point differing from the time point for the estimated temperature. The temperature change limit (delta T_{limit}) could be defined to be a fixed cooling rate, e.g. 2 or 3 degrees Celsius per minute. It could also be related to tables or the like of the cooling rate of the oil or to the actual cooling rate of another part of the vehicle, e.g. the engine block or cooling liquid, and could be adapted by taking relevant parameters into consideration.

As discussed in association with the use of a temperature limit for indicating a change of oil, also the accuracy of using the temperature change rate for indicating a change of oil may be considerably improved

if it is based on several determined temperatures. The temperature change rate limit (delta T_{limit}) could of course also in this case be fixed or based on a table, graph or algorithm. However, the cooling rate may also be related to one or several previous oil temperature change rates (delta T_{oil}) by multiplying the oil temperature change rate by a factor, e.g. by 1.5 or 3. It could also be possible to set the temperature change rate limit (delta T_{limit}) to the previous value of the oil temperature change rates (delta T_{oil}) setting the criteria that the cooling rate shall be slower as the oil cools down since the temperature difference between ambient temperature and the oil will decrease by time. However, it may be necessary depending on the accuracy in the determination of the temperature, e.g. the sensitivity of the temperature sensor, and the influence of possible disturbing elements, to use some tolerances.

According to an embodiment of the method may the method for detecting a change of engine oil include the steps of:

- determining the oil temperature T_{oil} at at least a first time point t_1, a second time point t_2 and a third time point t_3 to get the oil temperatures T_1, T_2 respectively T_3
- using the determined temperatures T_1 and T_2 for defining a temperature change rate limit (delta T_{limit})
- Using the determined temperature T_3 and a previous determined temperature in order to

determine an oil temperature change rate (delta T_3)

- using the defined temperature change rate limit (delta T_{limit}) for comparing with said oil temperature change rate (delta T_3) and if said oil temperature change rate (delta T_3) indicates a quicker cooling rate than said defined temperature change rate limit (delta T_{limit}) it is considered as an indication that there has been a change of oil.

The method may be performed such that when a further oil temperature determination is made will it be the "new" T_3 and "old" T_2 and T_3 will be "new" T_1 and T_2. The temperature change rate limit (delta T_{limit}) may be defined by $(T_2 - T_1)/ (t_2 - t_1)$ multiplied by a factor F and the oil temperature change rate (delta T_3) to be $(T_3 - T_2)/ (t_3 - t_2)$. These numbers will represent a negative value in the relevant cases, i.e. they represent a cooling of the oil. As long as the cooling rate is slowing down, the indication is that no change of oil has occurred. If the factor F is set to 1 will the negative value of the temperature change rate (delta T_3) be smaller than the negative value of the temperature change rate limit (delta T_{limit}), i.e. (delta T_{limit}) < (delta T_3). If it should be illustrated in a graph, having time on its X-axis and temperature on its Y-axis, will the temperature-time diagram show a graph having a slightly decreasing slope until the temperature of the engine oil has reached steady state at the ambient temperature if no oil change is made. If the oil is changed, a rather quick temperature drop is expected and the determined temperatures should show

(delta T_{limit}) > (delta T_3), i.e. the temperature graph will suddenly form a strong negative slope.
As discussed earlier, the exact criterion for indicating a change of oil may be discussed but it may be relevant to use that the negative slope should be twice as steep as the previous segment of the graph, i.e. F = 2 and (delta T_{limit})= previous (delta T_3) * 2 > (delta T_3).

However, specific values of the temperature change rate limit (delta T_{limit}) may be tried out.

As earlier discussed, expected temperature $T_{expected}$ of the oil may be estimated as a function of time for a vehicle having its engine turned off by the use of standard graphs or standard values for the oil temperature change. Different graphs or tables may be used depending on ambient conditions or the graph or values may be modified by using correction factor. By comparing with these graphs may relevant temperature limits (T_{limit}) and/or temperature change rate limits (delta T_{limit}) be decided in dependence of said standard graphs or standard values.

The defining of the temperature limit T_{limit} and/or said temperature change limit (delta T_{limit}) may include the use of determined temperatures of another part or system of the vehicle which will cool when the engine is shut off. This information could be used either alone and having a correspondence to relevant temperature limits or together with other parameters for deciding the temperature limits, e.g. as correction

factors for a graph of the oil temperature cooling sequence.

The other parts or system of the vehicle may be the cooling liquid of the vehicle, parts of the exhaust treatment system, the engine block, or other part. If there are temperature sensors located somewhere on the vehicle for monitoring the temperature, they may be relevant to use. Temperature sensors are normally present to monitor a temperature of a part which in some way is affected (heated) by the engine operation or the driving of the vehicle and will cool down when the engine or vehicle stop.

A possibility to indicate an unexpected drop of the oil temperature could be to construct a graph of the oil temperature versus time based on determined oil temperatures over a time interval and compare with a temperature versus time graph for another part or system of the vehicle having a temperature influenced by the operation of the engine. The graphs shall at least partly overlap each other along the time axis. From these graphs it may be possible to detect an increased temperature drop in the oil temperature graph having a certain magnitude delta T over a certain time interval. If there is no such corresponding temperature drop of the other part or system of the vehicle, or a drop below a certain magnitude, for the same time period, it may be decided there shall be an indication of a change of oil. This method is particularly useful for avoiding extreme ambient conditions, e.g. very hot or cold climate or a reduced temperature due to cooling

by water, to perform a wrong indication of a change of oil.

The oil temperature may be determined at regularly time intervals, e.g. may the temperature be determined and logged at least once every 30 minutes when the engine is turned off. Preferably is the temperature logged more frequent, every 10, 5 or 1 minute. To determine and log temperatures does not consume any essential amount of additional energy and could be made as much as desired within reasonable limits, e.g. may it be possible to log every second if desired. However, a log of a determined oil temperature every minute should be sufficient to provide an accurate method for indicating the existence of an oil change based on the method described herein. The logging may terminate if the temperature is below a certain temperature when it is not likely that an oil change should be performed, e.g. below 30 degrees Celsius. The determination and logging of oil temperature could be performed at least when turning on and turning of the engine. In case other measured data are of interest for performing the oil change indication, the data may be logged at corresponding times for the data logged to determine the oil temperature, e.g. to determine temperatures for another part or system of the vehicle which will cool when the engine is shut off.

In dependence of the time interval between the determination and/or logging of the temperatures, may temperature limit T_{limit} be decided to be a defined amount delta T lower than the oil temperature T_1 determined at the first time point t_1. This strategy

will function in particular if the temperature loggings are made with a rather short interval, e.g. every 5 minutes or more frequent. The strategy may work also for longer time intervals but is mainly intended for short intervals. It may also be desired, in particular if there are long intervals between the determined temperatures, to set the temperature limit T_{limit} in dependence of the temperature of the ambient surroundings.

It has been described that the oil temperature shall be determined by some measurement method. The most obvious choice is to use a temperature sensor which already is provided in the system and could be used for this purpose. However, if the sensor is located in an appropriate location, another sensor may be added to the system.

As previously discussed, the system described herein is to be used for indicating that a change of oil has been performed. This indication may be used alone or in combination with another method to build up a redundant system for positively indicating oil changes and avoiding indicating a change of oil when there has been none. Hence, the method may include that also a detection of change of an oil filter is used to verify the indication that there has been a change of oil. These systems could for example work together such that the present system, based on the indication of a change of oil as a function of the oil temperature, may have different levels of indications, e.g. a strong indication and a weak indication. If there is a strong indication, tit will be decided that there a change of

oil shall be logged regardless of the other indication system. If there is a weak indication, it is needed that the other indication system also indicates a change of oil in order to decide there has been a change of oil to be logged in the system.

The detection of change of an oil filter of a vehicle may be made by measuring a period of time required to achieve a known engine oil pressure when the engine is started. The measured period of time is compared to a known period of time for achieving the known oil pressure and it may be determined whether the oil filter has been changed since a previous start up. This method is for example disclosed in US 6,484,127.

The indications that there has been a change of oil may be logged directly into an electronic log book and the log book may also log the indication as a possible change of oil or, if the indication is considered certain, it is determined there has been a change of oil and it will be recorded in the log book that the engine oil has been changed.

The invention further relates to a system for detecting change of engine oil of a vehicle. The system comprises at least one temperature sensor in the oil system, at least one memory unit for storing the oil temperatures detected at different times and at least one comparator which compares the detected temperatures with a reference comprising an algorithm, a table or a graph in order to detect a temperature change of the oil deviating from an expected oil temperature. The reference may be based on standard curves for the

engine oil temperature change. These curves may be adapted for different outdoor temperatures. The system may further comprise a temperature sensor for detection of a part or system of the vehicle which is heated by the operation of the engine, e.g. the cooling system. The temperature sensor may be connected to the memory unit for storing of the temperature measurements to be used as a reference for the oil temperature measurements.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a schematic graph of the cooling of the oil temperature and the cooling water temperature when there has been no oil change

Fig. 2 shows a schematic graph of the cooling of the oil temperature and the cooling water temperature when there has been an oil change

DETAILED DESCRIPTION OF THE DRAWINGS

In figure 1 is shown schematically the temperature of the oil, drawn as a continuous line, and the temperature of the cooling liquid (in this case water), drawn as a dashed line, for a vehicle. In figure 1 is illustrated the temperature curve for the oil and cooling liquid in case there is no change of oil when the vehicle has stopped. At the starting point, T0, is the temperature of the oil and cooling liquid the same and corresponds to the ambient temperature if the vehicle not has been used for a while. When the engine is started at T0 will the temperature of the oil and cooling liquid start to rise until the temperatures will reach a state essentially corresponding to a

steady state of the temperatures of the oil and cooling liquid at a second time point T1. The temperature may of course fluctuate more or less and the temperature may rise and fall due to different driving condition, e.g. the temperature will rise if the vehicle is driven in a jammed traffic condition, heavily loaded or being in a hilly environment causing a heavy load on the engine. However, for the sake of simplicity when explaining the basic idea for the present invention, is the graph made for a vehicle which is driving under more or less similar conditions during its travel and thus reaches a steady state condition after a certain time indicated by T1 in the graph. The temperatures will thus be kept essentially constant until the engine is switched off and the vehicle stops at the time point indicated by T2 in the graph. After the engine is turned off will the temperatures of the cooling liquid and the oil start to drop having a typical rate of cooling down depending of the actual engine design, actual environment and where the temperature sensors are mounted. In the example shown through figure 1 the temperature drop of the cooling liquid and the oil has an essentially equal rate of cooling down. The temperature drop will continue until the temperatures has reached the ambient temperature unless the vehicle is restarted and the temperatures will start to rise again.

In figure 2 is once again shown the oil temperature (continuous line) and cooling liquid temperature (dashed line) for a vehicle but in this case is a change of oil performed after the vehicle has stopped

at time interval TOC (Time of Oil Change). The vehicle is assumed to have been driven during the same circumstances and the same ambient conditions as shown in figure 1 and thus shows the same characteristics until TOC. In this case is there a large drop of the temperature of the oil when the oil is changed at TOC. Hence, by following the temperature of the oil it will be possible to detect, and if desirable to log, that there has been a change of oil.

During normal circumstances a change of oil may be detected easily without comparing with the cooling liquid temperature, at least if the oil temperature is logged frequently, e.g. one measurement every minute, and the ambient conditions not are too extreme. Extreme ambient conditions could for example be extremely cold ambient temperature causing the oil temperature to drop extremely fast reminding of an oil change without actually performing a change of oil or replacing the oil with extremely hot, fresh oil, e.g by using fresh oil which has been stored in sunshine in a hot place. In at least the first case, i.e. an extremely cold environment, could it be helpful to compare the cooling curve of the oil temperature with the cooling curve of the cooling water in order to let a fast cooling of the oil temperature be mistaken for a change of oil. However, the cooling rate of the oil could also be correlated with an oil cooling curve which is dependent on the outdoor temperature instead of making actual comparisons with the cooling liquid temperature or cooling liquid cooling curve. In the case of changing oil in a very hot climate, using rather hot, fresh oil,

may it be hard to detect a change of oil unless frequent temperature measurements are made. Also in this case is it of course helpful to use a reference temperature from the cooling liquid temperature or correlate the oil cooling curve for the ambient temperature.

In figures 1 and 2 has only the temperature of the cooling liquid been exemplified to be used for reference temperatures in order to improve the reliability of the oil change detection method. However, other parts of the vehicle, e.g. the engine block, may also be used as a reference of the cooling rate of the vehicle in dependence of the ambient temperature. It is further obvious from the curve shown in fig. 2 that it would be easy in this case to detect an oil change due to the very quick cooling of the oil temperature during a short time period. It could thus be easy to decide that there has been a change of oil due to a large change in the cooling rate during this time interval without the need of making any comparison with other elements or outdoor temperature. Still another indication of that there has been an oil change is the slightly increasing temperature of the oil after the change has been performed due to heating of the oil from the surrounding, i. e. hot engine parts. Hence, a rapid cooling followed by a slightly heating of the oil may be used as an verification that there actually has been a change of oil.

In the above curves, it has been assumed that the oil temperature is measured directly. In most cases is this

the easiest and most reliable way to determine the actual oil temperature and thus get a reliable detection of an oil change. However, also other measurements may be made and in certain cases could measurements of other temperatures be more relevant. This may for example be the case if the oil temperature sensor is located at a place where a rather small volume of oil is in contact with a large mass of surrounding material which may influence the temperature of the oil. This may be particularly relevant in this case if the engine not is started soon after the oil change since the oil not will flow in the system but stay at one location why there may be fluid "hot spots" at these locations. Hence, in some cases an indirect measurement of some engine part may be relevant, e.g a temperature sensor on a relatively thin wall comprising a large volume of oil.

Figures 1 and 2 are intended to show the general idea of using a change of the oil temperature which not is considered to be normal as an indication that there has been a change of oil. The skilled person understands that she or he could use one or several determinations of the oil temperature, either by directly or indirectly measuring the oil temperature, and compare with previous temperature determinations made or by comparing with reference tables or graphs indicating normal temperatures or normal temperature change rates. Hence, there may be a wide variety of different ways of using at least one determined temperature of the oil in a vehicle as an indication of a change of oil.

CLAIMS

1. A method for detecting a change of engine oil of a vehicle wherein said method comprises the steps of:
   - determining the oil temperature (T_{oil}) at at least one time point,
   - defining a temperature limit (T_{limit}) and/or defining a temperature change rate limit (delta T_{limit}) of the oil temperature (T_{oil}),
   - using the defined temperature limit (T_{limit}) to compare with the determined oil temperature (T_{oil}), and/or using the temperature change rate limit (delta T_{limit}) to compare with an oil temperature change rate (delta T_{oil}) based on the determined oil temperature (T_{oil}), whereby a determined oil temperature (T_{oil}) below the defined temperature limit (T_{limit}), and/or an oil temperature change rate (delta T_{oil}) indicating a quicker cooling rate of the oil temperature (T_{oil}) than the temperature change rate limit (delta T_{limit}), is considered as an indication that there has been a change of oil.

2. The method according to claim 1 wherein said method is further defined to include:
   - determining the temperature (T_{oil}) of the oil at at least a first time point (t_1) and a second time point (t_2) to get a first (T_1) and a second (T_2) determined oil temperature respectively ,

- using the first determined oil temperature (T_1) at the first time point (t_1) for defining a temperature limit (T_{limit})
- using the defined temperature (T_{limit}) for comparing with the second determined oil temperature (T_2) at the second time point (t_2) and if the second determined oil temperature value (T_2) is lower than the temperature limit (T_{limit}), it is considered as an indication that there has been a change of oil.

3. The method according to claim 1 wherein said method is further defined to include:

- determining the oil temperature (T_{oil}) at at least a first time point (t_1), a second time point (t_2) and a third time point (t_3) to get a first (T_1), a second (T_2) and a third (T_3) determined oil temperature respectively,
- using the first (T_1) and second (T_2) determined oil temperature for defining a temperature change rate limit (delta T_{limit}),
- using the third determined oil temperature (T_3) and a previous determined oil temperature (T_2) in order to determine an oil temperature change rate (delta T_3),
- using the defined temperature change rate limit (delta T_{limit}) for comparing with said oil temperature change rate (delta T_3) and if said oil temperature change rate (delta T_3) indicates a quicker cooling rate than said defined temperature change rate limit (delta

T_{limit}) it is considered as an indication that there has been a change of oil.

4. A method according to any previous claim wherein an expected temperature ($T_{expected}$) of the oil is estimated as a function of time for a vehicle having its engine turned off by the use of standard curves or standard values and said temperature limit(T_{limit}) and/or said temperature change rate limit (delta T_{limit}) is decided in dependence of said standard graphs or standard values.

5. A method according to any of the previous claims wherein the defining of said temperature limit (T_{limit}) and/or said temperature change rate limit (delta T_{limit}) further comprises the use of determined temperatures of another part or system of the vehicle which will cool when the engine is shut off.

6. A method according to claim 5 wherein said other part or system of the vehicle includes a cooling liquid of the vehicle.

7. A method according to claim 5 or 6 wherein said part or system includes an exhaust system and/or an engine block of the vehicle.

8. A method according to any of claims 5 - 7 wherein a graph of the oil temperature versus time is constructed based on determined oil temperatures over a time interval and compared

with a temperature versus time graph for another part or system of the vehicle having a temperature influenced by the operation of the engine, said graphs at least partly overlapping each other along the time axis whereby an increased temperature drop in the oil temperature graph having a magnitude delta T over a certain time interval not having a corresponding temperature drop of the other part or system of the vehicle for the same time period is decided to indicate a change of oil.

9. A method according to any previous claim wherein the oil temperature is determined and logged at regularly intervals at least once every 30 minutes when the engine is turned off.

10. A method according to any previous claim wherein the oil temperature is determined when the engine is turned off and when the engine is turned on.

11. A method according to claim 8 or 9 wherein the temperature is determined at corresponding times for another part or system of the vehicle which will cool when the engine is shut off.

12. A method according to any previous claim wherein said temperature limit (T_{limit}) is set in dependence of the temperature of the ambient surroundings.

13. A method according to claim 2 wherein said temperature limit (T_{limit}) is decided to be a defined amount delta T lower than said first oil temperature (T_1) determined at the first time point (t_1).

14. A method according to any previous claims wherein the oil temperature is determined by the use of a temperature sensor in the engine oil system.

15. A method according to any previous claim wherein a detection of change of an oil filter is used to further verify the indication that there has been a change of oil.

16. A method according to claim 15 wherein the detection of change of an oil filter of a vehicle is made by measuring a period of time required to achieve a known engine oil pressure when the engine is started and comparing the measured period of time to a known period of time for achieving the known oil pressure to determine whether the oil filter has been changed since a previous start up.

17. A method according to any previous claim wherein said indication that there has been a change of oil is used for determine if there has been a change of oil and, if it is determined there has been a change of oil, it will be recorded that the engine oil has been changed.

18. A system for detecting change of oil of an engine of a vehicle wherein said system comprising at least one temperature sensor in the oil system, at least one memory unit for storing the oil temperatures detected at different times and at least one comparator which compares the detected temperatures with a reference comprising an algorithm, a table or a graph in order to detect a temperature change of the oil deviating from an expected oil temperature.

19. A system according to claim 18 wherein the reference is based on standard curves for the engine oil temperature change.

20. A system according to claim 18 or 19 wherein the system comprises a further temperature sensor, for detection of a part or system of the vehicle which is heated by the operation of the engine, and is connected to the memory unit for storing of its temperature measurements to be used as a reference for the oil temperature measurements.

FIG. 1

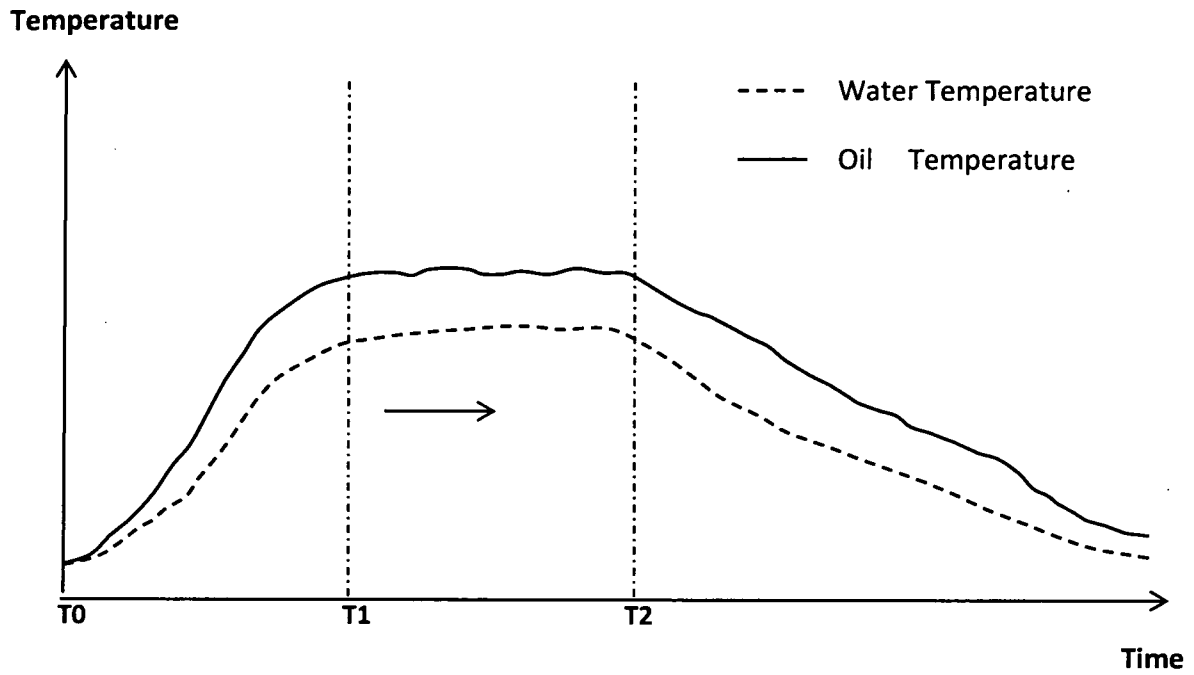
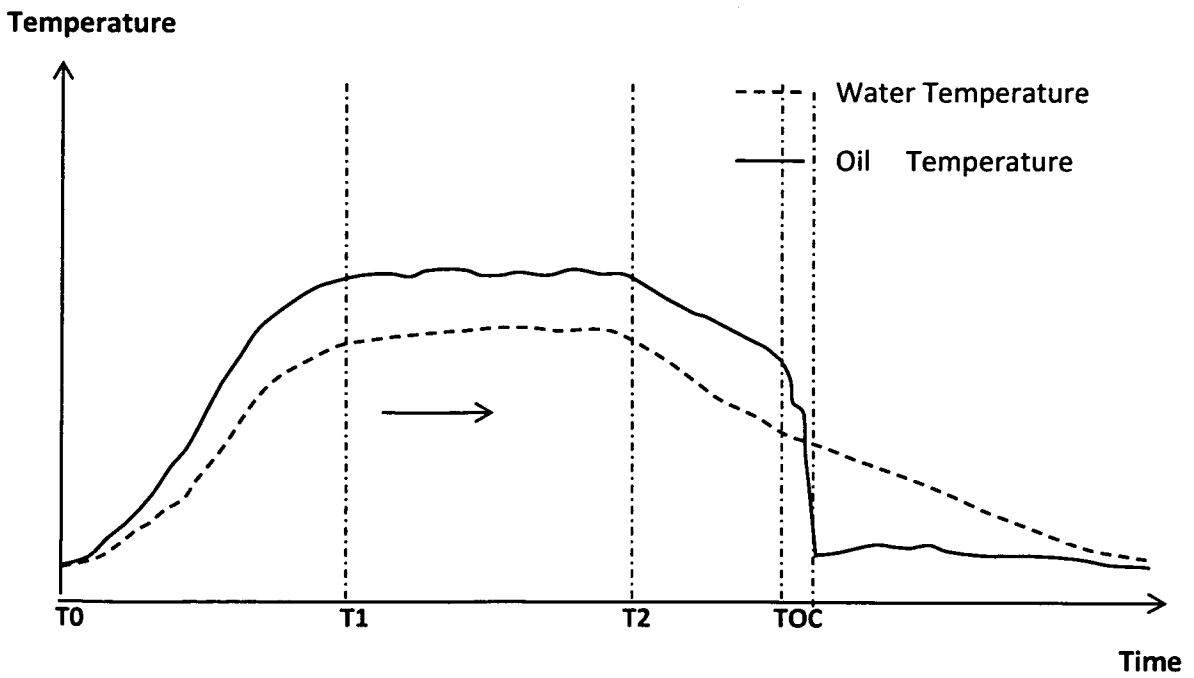

Temperature
Water Temperature
Oil Temperature
T0
T1
T2
Time

FIG. 2


Temperature
Water Temperature
Oil Temperature
T0
T1
T2
TOC
Time

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/005635

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01M11/04 F01M11/10
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F01M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

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Y	US 2003/150256 A1 (JAKOBY BERNHARD [AT] ET AL) 14 August 2003 (2003-08-14) paragraphs [0006] - [0012] -----	1,9-12, 14-20
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"E" earlier application or patent but published on or after the international filing date

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
3 August 2012	10/08/2012

Name and mailing address of the ISA/	Authorized officer
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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/005635

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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