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FAILURE MECHANISMS CAUSED BY MOTOR OIL DEGRADATION AND THEIR STUDY AS PART OF EXPERTISE OF TECHNICAL CONDITION OF GASOLINE CAR ENGINES

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МЕХАНІЗМИ ВИНИКНЕННЯ НЕСПРАВНОСТЕЙ, ВИКЛИКАНИХ СТАРІННЯМ МОТОРНОГО МАСТИЛА, І ЇХ ДОСЛІДЖЕННЯ В ЗАВДАННЯХ ЕКСПЕРТИЗИ ТЕХНІЧНОГО СТАНУ БЕНЗИНОВИХ ДВИГУНІВ АВТОМОБІЛІВ

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Introduction.

It is known that the cooling and the lubrication of the engine parts are the main functions of the motor oil and must be implemented in the entire range of engine operating modes. To meet these requirements, the engine oil must have certain properties or quality [1]. However, in some cases, the cooling and lubricating functions of the oil may be impaired. Such cases include the use of inappropriate quality oil, abnormal operating conditions, as well as the entry of various foreign substances into the oil (Fig. 1).

As a result, the engine can receive various kind of damage due to the lubrication failure of the rubbing parts. In practice, this may be the reason for the owner's complaints on the quality of the maintenance work, earlier performed by the technical service organization, or even on the quality of the vehicle produced by the manufacturer and sold by the dealer. The dispute between these parties can subsequently become the subject of an auto-technical expertise on the vehicle engine that will carry out a study of its technical condition in order to determine the fault cause [2].

Analysis of recent research and publications.

The main problems with engine oiling in operation is often associated with improper oil additives for the engine or their degradation (oil aging). For example, motor oil may be lacking in the required amount of some additives that are necessary for the reliable engine operation, including extreme pressure agents, antioxidant, detergent, anti-corrosion, antiwear, friction modifiers, dispersants, etc. [3, 4]. Moreover, in a number of cases it is found that all the necessary additives were present in original oil, but they were depleted (degraded) as a result of oil aging [5, 6].

Another problem with the quality of motor oil is often revealed during an expert study of the engine fault causes [2]. So, there are difficulties in correctly determining the symptoms of breaking of the oil working properties. If the symptoms are determined non-correctly or non-completely, it will be difficult to confirm in study that oil is the cause of such fault.

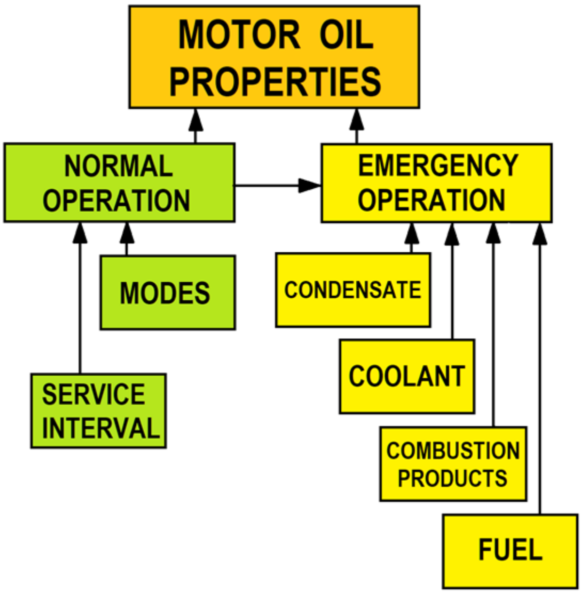


Figure 1 – General effects of various factors on the engine oil properties in operation [2]

It is known that in the oil aging process there is a change in the concentration, structure and efficiency of oil additives due to decomposition, interaction with fuel combustion products, oil oxidation, filter elements and parts [7]. For example, the base number decrease (concentration of detergents) in operation is accompanied by the accumulation of acidic products in oil, which can cause corrosive wear of the parts. Particularly dangerous is the entry of light fuel fractions into oil; they have low oxidation stability [8]. When contaminated with fuel, motor oil oxidizes much faster, since the organic acids and deposits formed during oxidation further deteriorate the oil quality [9]. As a result, it is possible the oil viscosity reduce with its properties deterioration. But more often, on the contrary, there is an intensification of the processes of sludge and slag deposition in the engine up to the strong oil thickening and the sediment formation [1].

Usually, the state of motor oil degraded for one reason or another is described by the terms «slag» (soft deposits) and «varnish» (hard or varnish deposits) [10]. However, this division is conditional, since the real picture of motor oil conditions is much broader [2, 11]. Moreover, one of the main factors of catastrophically rapid oil aging is the use of inappropriate fuel [2, 8, 9].

The term «inappropriate» in this context does not mean individual impurities, for example, of diesel fuel (its content in gasoline leads mainly to octane decrease and combustion problems, including knocking), but a certain gasoline chemical composition. It is the deviation in the fuel composition that can cause the rapid oil aging and the deposit formation on the walls [12].

The effect of fuel on motor oil is obviously due to the lack of a complete sealing of the cylinder volume by the piston rings. Unvaporized fuel settles on the cylinder walls where it mixes with oil and can be dropped off into the oil pan by the piston rings. In addition, not only droplets and fuel vapors, but also the breakthrough of the products of combustion through the piston rings into the crankcase can have a chemical effect to oil and cause a change in its properties [13].

As practice shows, such changes in motor oil are found and described in many sources [1, 2, 5, 8]. At one time, the cause of these changes caused the various controversies, but in recent years, evidence has been obtained that the cause of the changes can be the effect of gasoline, which has specific properties [2, 14]. Accordingly, when studying the cause of an engine fault, the main question becomes the cause for the acquisition of such properties by gasoline. However, the lack of sources of such gasoline in some local markets makes such cases rare and the available data incomplete. This feature, on the whole, makes it difficult to study and describe this phenomenon in detail.

The goal of the work is to develop a method that can be used for the tasks of auto-technical expertise and can help clarify the types and symptoms of various effects on motor oil, as well as determine the causes for the changes in its properties when the engine is running.

To achieve this goal, it is necessary to analyze the various factors that affect the engine in vehicle operation, including the basic regularities of their action on the fuel used.

Main material presentation.

Motor oil can change its properties as a result of the following four main operational causes, including [1, 2]:

1) faults of the engine systems, as ventilation, cooling, fuel supply, as a result of which the foreign substances, including fuel and operating fluids, enter oil and affect its properties,

2) abnormal modes and conditions in the car operation that could affect the oil properties,

3) non-standard additives in to oil, for example, in order to improve some engine characteristics,

4) incorrect choice of oil, it does not correspond to the engine requirements and the specifications of the car manufacturer, as a result oil properties deteriorate rapidly.

Indeed, accelerated aging of normal quality oil often appears under the faults of engine systems effect. Such systems and their faults include:

1) engine ventilation system, when a large amount of water condensation forms in the engine during operation,

2) cooling system, if coolant gets into the oil,

3) fuel system, when a large amount of fuel enters oil and causes its dilution.

In addition, various foreign substances can enter oil and lead to its rapid aging if the fuel properties do not meet the requirements of standards and regulations [16]. Most of these faults can be determined by diagnostic testing, with the exception of the analysis of the properties of fuel and oil, carried out in specialized chemical laboratories [17].

The use of special modes and conditions in the car operation can effect on oil and its rapid aging. Such conditions often include long service intervals when they do not correspond to the engine operating conditions and / or the properties of using oil, short starting periods without complete engine warm-up, especially in the cold season, as well as long-term idling [2, 6].

The main symptoms of the use of such modes and car overrun are often associated with the loss of detergent properties by oil, which directly leads to increased carbon formation in the engine internal cavities (Fig. 2). Such changes include the formation of significant deposits with special properties on the inner surfaces of the engine walls – greasy, loose, with large particles and sediment into motor oil [18]. In some cases, the piston rings are blocked / coked in the piston grooves [2]. Practice shows that these processes are not always the symptoms of natural aging of normal quality oil or the use of oil of inappropriate quality.

a b

Figure 2 – Typical examples of changes in the properties of motor oil in the form of solid high-temperature (a) and greasy low-temperature deposits (b)

Influence of the fuel composition and properties on the oil aging process.

It is known that in the gasoline production, one of the main tasks is to ensure the required octane number (RON). It is possible to produce gasoline with a high octane number in two ways: a complex technological one, which causes a high cost of the resulting product, and a simpler and cheaper one, when the special additives (antiknock agents) input into cheap gasoline. Thus, one of the currently widespread methods of increasing the gasoline octane number is based on the addition of methyl tert-butyl ether (MTBE). In addition, isopentane, isooctane, neohexane, benzene, toluene, acetone, ethyl alcohol, etc. are also used as antiknock agents [5].

In past years, the addition of ferrocene (containing iron compounds) active components to fuel was widely used to increase the octane number of gasoline [2, 5]. At present, the use of ferrocenes does not comply with international environmental standards; therefore such additives are not used in high-quality fuel [19]. However, in addition to ferrocenes, there can be more serious changes in gasoline [2], which directly cause accelerated oil aging (Fig. 3):

1. Gasoline contains impurities – waste of petrochemical production, added to reduce the cost of fuel.

So, in the production of synthetic rubbers, by-products are formed, which contain a lot of unsaturated hydrocarbons. Such substances can be added to gasoline to increase the octane number. During the fuel combustion, especially at the high compression ratio typical of modern engines, a high temperature is reached in the combustion chamber, which causes the formation of nitrogen oxides. In the presence of unsaturated hydrocarbons, nitrogen oxides form nitroesters.

a b

Figure 3 – Typical examples of changes in the properties of motor oil when exposed to low-quality fuel: sediment formation (a) and its transformation into a rubbery mass (b)

These are non-volatile compounds, which easily settle on the cylinder walls and are removed into the engine crankcase pan by oil scraper rings. At temperatures of about 100°C typical for oil in the crankcase pan, nitroesters decompose to form acids. Further, the acids quickly react with alkaline oil additives, and then form soap and cause quick oil thicken until it turns into rubbery sediment with a complete loss of fluidity [14].

2. Gasoline contains unsaturated hydrocarbons, which are intermediate products of the gasoline production process itself.

It is known, the finished products of any chemical factory are strictly controlled. However, the control of semi-finished products can be weaker. Rejects in individual batches of the product are possible; the losses during intermediate operations associated with spillage or evaporation of components may not be completely excluded too. The octane number of the intermediate is high, but it can contain significant amounts of unsaturated hydrocarbons. If they enter in gasoline, the process in the engine follows the same chain as in the case of waste above – nitroesters-acids-soap [2, 14].

3. Gasoline contains some substances in excess of the permissible amounts.

For example, low-octane grade gasoline can be converted to high-octane grade by adding alcohol as an inexpensive antiknock agent. At the same time, the share of ethyl alcohol can easily be increased to 20%, though the current standards and regulations restrict the content of this component of 5-10%. The chemical action between the products with motor oil leads to partial oxidation of ethanol (products of incomplete combustion of gasoline with a high ethanol content). As a result, a viscous (thickening) additive precipitates in oil.

This case is especially typical for the modern engines with low-viscosity (energy conserving) oils with a viscosity of SAE 5W20 or 0W20, which is achieved by a significant increase in the content of the thickening additive.

In fact, this triggers the process of rapid oil aging. This process does not stop even with the subsequent refueling of the car with high-quality fuel – to stop the oil aging, as a rule, is possible only by means of its early replacement. As a result, when the car runs several thousand, and sometimes hundreds of kilometers, the layer of deposits increases very fast, simultaneously the oil level in crankcase pan falls down too much. It leads to a breakdown in oil supply due to its insufficient level in the crankcase, although the oil did not leave the engine.

Common to all of these ways of changing the gasoline properties is that they are poorly recognized using standard analysis methods that are usually used in fuel quality control. So, the main characteristics of gasoline, most of which are physical parameters (octane number, volatility, etc.), remain within acceptable values.

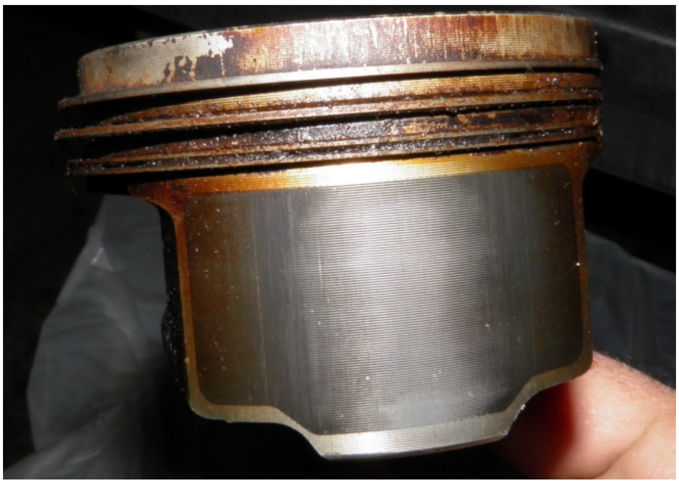
Method of investigating the faults associated with oil quality, when providing auto-technical expertise.

There is a number of methods that make it possible to diagnose oil properties changing during operation [20, 21]. However, the methods use for cars of the mass sector, especially for operative detecting deviations, is actually impossible both due to the high cost of equipment and due to absence of all needed functions in the car on-board diagnostics systems. As a result, when conducting research within the framework of an auto-technical expertise, a change in motor oil properties is recorded only at the final stage of operation, just after failure. Then it is difficult to determine all the causal relationships between the failure and the oil properties, that does not allow to detect exactly and immediately whether the change in the oil properties could cause the fault.

By itself, a deviation in the oil properties is not at all necessarily the cause of the engine fault – it is equally important to find a correspondence between the damage on the parts and the deviations in the oil properties that caused them. First of all, the symptoms of changes in oil properties should be divided according to the nature of the effect on the engine into general and local. So, general simptoms of changes in oil properties can be designated the volumetric changes, for example, the appearance of a sediment in the volume of oil, a significant increase in viscosity up to loss of fluidity, as well as strong carbon formation and deposits on the walls [2, 5, 9].

Usually, such change in properties leads to decrease in the oil supply to individual or even to all friction pairs, at some or all engine operating modes, that depends on the degree of change in properties and the rate of such change. The resulting increase in viscosity (thickening) of oil prevents normal lubrication and cooling of the bearings, and the formation of sediment in the oil volume can partially or completely close the oil pump strainer. This will cause a breakage of lubrication for all bearings, regardless of engine operating mode, temperature and other parameters.

In addition to general changes in properties, local problems are also possible. They conditionally include the deterioration of certain oil properties, for example, detergents. The symptom of this process appears in view of local deposits are formed on certain surfaces. An example is the formation of significant deposits on the piston ring sealing zone, which is accompanied by blocking of the grooves in the oil scraper rings, and in severe cases, all the piston rings in the piston grooves (Fig. 4). Such picture is more often observed when using oil that is not intended for the operating conditions of the engine and is not designed for high loads and temperatures [2].



a

b

Figure 4 – Blocking of the grooves in the oil scraper rings (a) and the entire piston sealing zone (b) due to the use of oil that is not suitable for the engine.

Obviously, at the preliminary stage of expert examination of a faulty engine, it is not always possible to determine, that the fault is due to the oil properties. In this case, it is advisable to take samples of oil and fuel, and save them. If in the process of subsequent engine disassembly, a suspicion of a connection between the oil properties and engine damage is confirmed, their research will be necessary.

On the other hand, you should separate the cause of the fault and its consequences. In many cases, a change in the oil properties is caused by the degradation of its additives. For example, the degradation of thickening additives usually results in sludge formation as described above. At the same time, strong carbon formation can be associated with the loss of properties of other additives, including detergents and antioxidants.

Features of expert study in the presence of symptoms of oil exposure to fuel.

For gasoline engines, one of the main factors of oil degradation can be fuel [17], if it contains the strongest substances, including the already mentioned unsaturated hydrocarbons and alcohols. When even small quantities of them enter the crankcase pan through the piston rings, such substances can cause rapid changes in oil.

Based on this, in some of the most difficult cases, it may be necessary not only to determine the fuel and oil properties for comparison with data of regulatory documents on the main physical and chemical parameters. In addition, it is necessary to study the chemical composition using spectral analysis methods – to accurately determine the additives that make up the oil, as well as foreign substances and contaminants [17]. All these data are used further to study the causes for the change in oil properties (if found) and its effect on the operation of engine units and parts.

When it is required to determine the cause why oil has lost its main properties and has turned into a rubbery mass, the chemical research occurs the serious difficulty for specialized laboratories. The main reason for the difficulty follows from the fact that conventional research of fuel and oil quality by standard methods has limited applicability. So, it prevents for answering the question: whether there is a causal relationship between the properties of fuel and changes in oil properties. In many practical cases, such research provide nothing. For example, fuel was filled too long ago and was used up just as long ago. In such case there will be no traces of foreign substances in the fuel sample.

It is clear that if there are no signs of the effect of fuel with abnormal properties on the engine, or they cannot be found, it is useless to conduct oil research. The results simply have nothing to apply, and they do not say anything. This is especially true of some attempts to determine the cause of engine fault only by analyzing the properties of fuel and oil. In fact, when the cause of the changes in motor oil properties is not obvious, further attempts to detail the study only increase the uncertainty. In this situation it seems appropriate to use logical methods.

Results of the logical analysis of fuel to oil exposure.

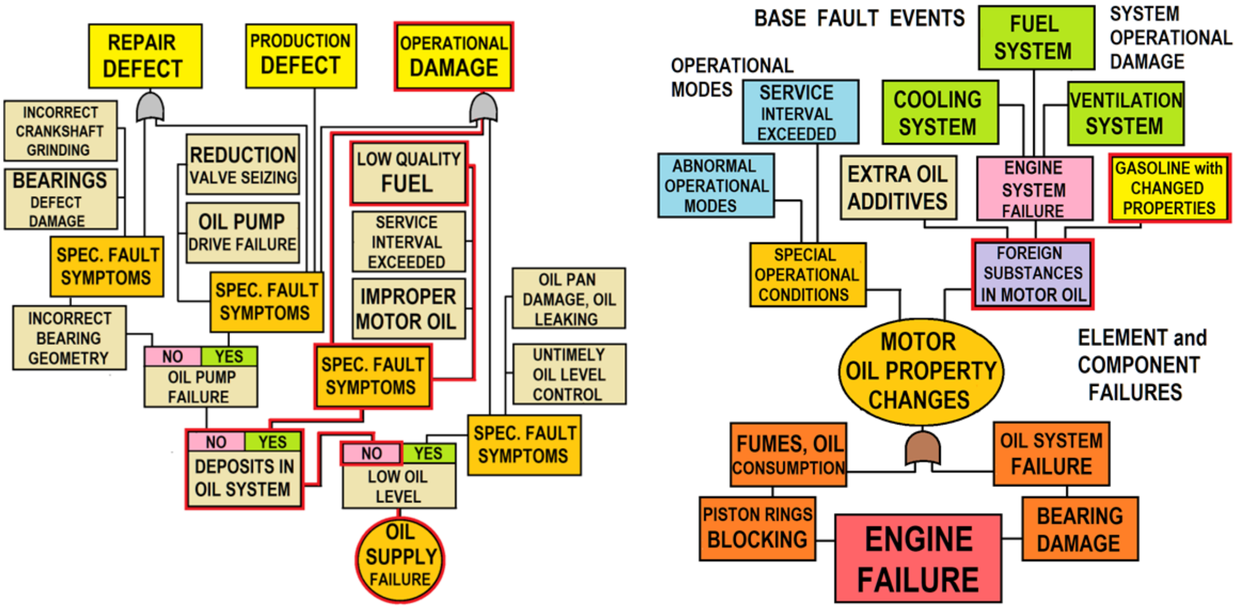
It is known that when any factor affects the technical condition of the engine, the cause-and-effect relationships of emerging faults can be structured and presented as a logical graph [22]. In this case, it becomes possible to practically use some available data when determining the causes of engine faults.

So, when fuel effects on motor oil, it is possible to use the already known results of logical analysis of internal combustion engine damage. If a lubrication failure is considered [15], a part of the graph with the specifying signs (Fig. 5a) can be selected for further research.

For practical use in the tasks of auto-technical expertise, it is necessary to expand and detail that part of the general graph of this type of damage, which describes the effect of fuel with changed properties. To this purpose, it is first advisable to identify all types of effects on motor oil, after that to find out which of them are due to fuel. As severe changes in oil properties usually lead to engine failure (and this is often observed in practice [2]), therefore the causal relationships between various factors and motor oil properties can be represented as the following logical graph (Fig. 5b).

This graph, as well as the logical circuit of specifying features (Fig. 5a), gives only a general picture of the logical circuit, since it takes into account the main events, but does not indicate their main symptoms. In addition, only some of the events indicated in Fig. 5b are associated with fuel exposure. Therefore it is necessary to consider in more detail the causes and symptoms of fuel with altered properties effect on motor oil and engine failure.

Consider the data that were obtained in various expert studies over a long period [2] and associated with changes in motor oil properties. When analyzing this data, the main attention should be paid to the sources of the appearance of gasoline with altered properties. This can help to determine the event underlies the entire chain of this type of fault mechanism. Analysis of the fuel market and known cases of motor oil exposure to fuel leads to a variety of possible causes of entry of foreign substances in gasoline. Among them, the following can affect the rapid oil aging:



a b

Figure 5 – Description of the failure event when abnormal changing the motor oil properties using a logical graph: a) the symptoms of oiling failure when oil exposure to fuel (logical analysis is performed in the direction from bottom to top [15], logical circuit marked by red), b) a simplified logic graph for describing an engine failure event as a result of a general change in motor oil properties in operation

1) non-market regulation of pricing in the fuel market, which is typical for some countries, especially during crisis periods in the economics,

2) presence of chemical plants in considering area,

3) weak control over the participants of the fuel market by the state regulator,

4) insufficient control of environmental services over disposal and utilization of industrial waste.

Without going into a detailed description of each of these causes, the following can be noted. The modified fuel does not necessarily affect the motor oil. For the effect to become noticeable, certain conditions or some secondary concomitant factors are necessary. They allow and / or enhance motor oil exposure to fuel. In particular, it may be some design factors, which include the following:

1) fuel type: failures due to oil exposure to the changed fuel are noted only for gasoline engines,

2) compression ratio: the engines with a low compression ratio are less sensitive to fuel characteristics,

3) the year of manufacture of the car: the effect is similar to the compression ratio, since the engines of previous years, as a rule, had a low compression ratio,

4) gasoline octane number: it also depends on the design of the engine and its compression ratio,

5) the initial oil viscosity is one of the most important parameters, it is given in the car operation manual and can be considered as a constructional parameter.

In addition to constructional ones, there are also accompanying operational factors that enhance of motor oil exposure to modified fuel and the engine as a whole, and this action depends on the vehicle driver:

1) average vehicle speed: this extremely important operational parameter determines the operating interval in hours between services and oil life by the engine operating time in motor vehicle hours,

2) service mileage interval: the parameter refers to constructional parameters, because it is set by the car operating manual, but under some conditions it can be changed in one direction or another by the driver, that in fact makes it operational parameter.

It should be also noted there is another group of operational factors that depend on the driver conditionally. This includes, for example, the number of oil refineries, fuel storage bases and gas stations in the region of operation. Usually, in general, the more there are, the less the probability the modified fuel will get into the fuel tank of a particular car when refueling it.

Despite the generally understandable nature of causal relationships, it is not yet possible to obtain the reliable quantitative estimates of all the factors above. The main difficulty is that there is no unambiguous correspondence between the causes for the appearance of gasoline with altered properties and the results of motor oil exposure to it. Also the above processes are random in nature. As a result, attempts to give any mathematical description of the problem, as it is usually done, in order to estimate the probability of this type of fault, are difficult and do not lead to any equations that are useful for practical application.

In such conditions, it is advisable to apply the structuring of the fault mechanisms based on logical-probabilistic methods, including the fault tree analysis (FTA) method. This makes it possible to use the logical graphs which have already been built for other types of engine faults [15]. Then, taking into account the structural composition of causes, symptoms and operating factors above, it is possible to obtain a fairly simple logical graph for the engine failure in case of motor oil exposure to altered fuel (Fig. 6).

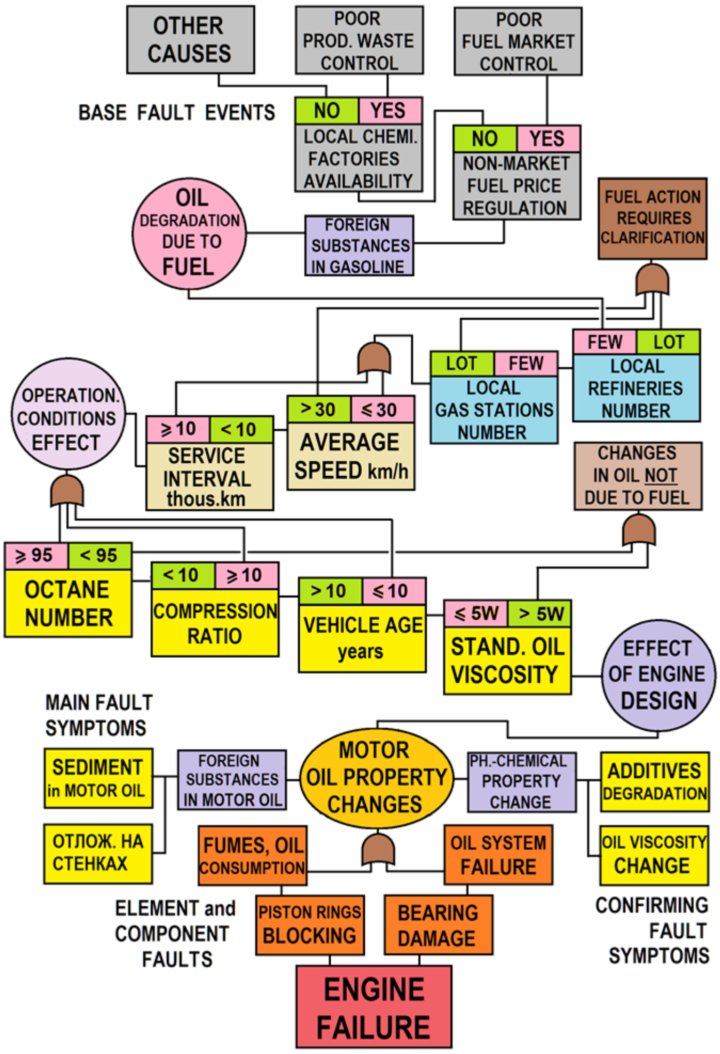


Figure 6 – An example of a description of the causal relationship between the appearance of fuel with altered properties and the engine failure using a logical graph

The algorithm for determining the failure cause means analyzing along the graph in the direction from the engine failure event. In this case, the graph takes into account the entire mechanism of the damage occurrence and development, starting from the base events that initiate the failure and actually determine the failure causes. This makes it possible to use the logical method in expert practice for a preliminary selection the research direction and further clarification the failure causes. At the same time, the graph includes and takes into account practically all known types of motor oil exposure to fuel. With a sufficiently high rate of logical graph details, this helps to avoid gross errors in determining the engine failure cause.

Conclusion

Out of the known faults that occur in the automotive engine operation due to changes in the motor oil properties, the most serious in terms of consequences induced are those caused by gasoline if it has deviations from normal composition and contains various abnormal substances, including unsaturated hydrocarbons and alcohols. The strongest effect of these substances on motor oil properties is observed in modern engines with high compression ratio, when they are operated on low-viscosity oils at low speeds at extended service intervals. This effect is of general nature and can cause rapid degradation of oil additives, sludge formation and engine failure due to poor bearing lubrication. At the same time, the analysis of the fuel and oil properties in specialized chemical laboratories does not always allow us to accurately determine the cause-and-effect relationship between the engine damage and the changes in the fuel and oil properties. That is why there is a reason to believe that the logical methods may be promising for the practical determination of this type of fault causes when conducting an expert study of engine technical condition.

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ABSTRACT

Sarayev A.V., Khrulev A.E. Failure mechanisms caused by motor oil degradation and their study as part of expertise of technical condition of gasoline car engines. Visnyk of National Transport University. Series «Technical sciences». Scientific and Technical Collection. – Kyiv. National Transport University, 2021. – Issue 1 (48).

The article considers the main symptoms and causes of accelerated motor oil aging in the gasoline engine operation. This process is revealed when conducting auto-technical expertise and is caused by motor oil being exposed to various constructive and operational factors.

The object of the study is the automotive internal combustion engine affected by fuel and motor oil that have abnormal properties.

The goal of the work is to develop a method that can be used for the tasks of auto-technical expertise and can help clarify the types and symptoms of various effects on motor oil, as well as determine the causes for the changes in its properties when the engine is running.

The research method is experimental-theoretical and includes the analysis of a large amount of data that were obtained during auto-technical expert research and demonstrated how various factors affect motor oil properties. To solve the problem, an algorithm for logical analysis has been developed that determine the nature of motor oil exposure to fuel. It describes the causal relationships between the failure event and the underlying events that initiate the change in oil properties. A logical graph is obtained for the analysis of causal relationships and determination of the failure cause due to lack of bearing lubrication that occurs as a result of oil exposure to fuel, which includes the formation of deposits, sediment, changes in oil viscosity.

The practical application of the method is most expedient in the tasks of auto-technical expertise of engine faults. The obtained results help avoid gross errors in determining the cause of the formation of sediment in oil and/or deposits on the walls.

Based on large factual material, it has been determined that the processes of oil exposure to fuel are random. However, attempts to obtain a mathematical description of the problem in order of assess the probability of this type of failure are complex and do not lead to any useful equations for practical application. In such conditions, the use of the developed logical algorithm becomes the most expedient, especially when determining the causes of engine failures, when they are caused by the use of abnormal fuel.

KEYWORDS: INTERNAL COMBUSTION ENGINE, FUEL, OIL, DEGRADATION, FAILURE.

РЕФЕРАТ

Сараєв О.В. Механізми виникнення несправностей, викликаних старінням моторного мастила, і їх дослідження в завданнях експертизи технічного стану бензинових двигунів автомобілів / О.В. Сараєв, О.Е. Хрулєв // Вісник Національного транспортного університету. Серія «Технічні науки». Науково-технічний збірник. – К.: НТУ, 2021. – Вип. 1 (48).

У статті розглянуті основні ознаки та причини прискореного старіння моторного мастила в експлуатації бензинових двигунів, що виявляються при проведенні автотехнічної експертизи та викликаються комплексною дією різних конструктивних і експлуатаційних факторів.

Об'єкт дослідження – двигун внутрішнього згоряння при впливі палива і моторного мастила, що мають нештатні властивості.

Мета роботи – розробка методу, який може застосовуватися для завдань автотехнічної експертизи й дозволяє уточнювати види та ознаки різних впливів на моторне мастило, а також визначати причини зміни його властивостей в експлуатації двигунів.

Метод дослідження – експериментально-теоретичний, включає аналіз великої кількості даних, отриманих при проведенні автотехнічних експертних досліджень, про вплив різних чинників на властивості моторного мастила. Для розв'язання проблеми розроблено алгоритм логічного аналізу характеру впливу палива на мастило, що описує причинно-наслідкові зв'язки між подією відмови та базисними подіями, що ініціюють зміну властивостей мастила. Отримано логічний граф для аналізу причинно-наслідкових зв'язків і визначення причини відмови через порушення змащення підшипників внаслідок впливу палива на мастило, в тому числі при утворенні відкладень, осаду, зміну в'язкості мастила.

Практичне застосування методу найбільш доцільно в задачах автотехнічної експертизи несправностей ДВЗ. Отримані результати дозволяють уникнути грубих помилок у визначенні причини утворення осаду у мастилі або відкладень на стінках.

На підставі великого фактичного матеріалу встановлено, що процеси впливу палива на моторне мастило мають випадковий характер, однак спроби дати якийсь математичний опис проблеми, з метою оцінити ймовірність появи несправності даного виду, ускладнені й не призводять до отримання будь-яких залежностей, корисних для практичного застосування. В таких умовах використання розробленого логічного алгоритму стає найбільш доцільним, особливо, при визначенні причин несправностей ДВЗ, викликаних використанням нештатного палива.

КЛЮЧОВІ СЛОВА: ДВИГУН ВНУТРІШНЬОГО ЗГОРЯННЯ, ПАЛИВО, МАСТИЛО, ДЕГРАДАЦІЯ, ВІДМОВА.

РЕФЕРАТ

Сараев А.В. Механизмы возникновения неисправностей, вызванных старением моторного масла, и их исследование в задачах экспертизы технического состояния бензиновых двигателей автомобилей / А.Э. Хрулев, А.В. Сараев // Вестник Национального транспортного университета. Серия «Технические науки». Научно-технический сборник. – К.: НТУ, 2021. – Вып. 1 (48).

В статье рассмотрены основные признаки и причины ускоренного старения моторного масла в эксплуатации бензиновых двигателей, выявляемого при проведении автотехнической экспертизы и вызванного комплексным действием различных конструктивных и эксплуатационных факторов.

Объект исследования – двигатель внутреннего сгорания при воздействии топлива и моторного масла, имеющих нештатные свойства.

Цель работы – разработка метода, применимого для задач автотехнической экспертизы и позволяющего уточнять виды и признаки различных воздействий на моторное масло, а также определять причины изменения его свойств в эксплуатации двигателей.

Метод исследования – экспериментально-теоретический, включает анализ большого количества данных, полученных при проведении автотехнических экспертных исследований, о влиянии различных факторов на свойства моторного масла. Для решения проблемы разработан алгоритм логического анализа характера воздействия топлива на масло, описывающий причинно-следственные связи между событием отказа и базисными событиями, инициирующими изменение свойств масла. Получен логический граф для анализа причинно-следственных связей и определения причины отказа из-за нарушения смазки подшипников вследствие воздействия топлива на масло, в том числе, при образовании отложений, осадка, изменении вязкости масла.

Практическое применение метода наиболее целесообразно в задачах автотехнической экспертизы неисправностей ДВС. Полученные результаты позволяют избежать грубых ошибок в определении причины образования осадка в масле и/или отложений на стенках.

На основании большого фактического материала установлено, что процессы воздействия топлива на моторное масло носят случайный характер, однако попытки дать какое-либо математическое описание проблемы с целью оценить вероятность появления неисправности данного вида, затруднены и не приводят к получению каких-либо зависимостей, полезных для практического применения. В таких условиях использование разработанного логического алгоритма становится

наиболее целесообразным, особенно, при определении причин неисправностей ДВС, вызванных использованием нештатного топлива.

КЛЮЧЕВЫЕ СЛОВА: ДВИГАТЕЛЬ ВНУТРЕННЕГО СГОРАНИЯ, ТОПЛИВО, МАСЛО, ДЕГРАДАЦИЯ, ОТКАЗ.

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