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THE PROBLEMS OF BIOPOLLUTION WITH JET FUELS AND THE WAY OF ACHIEVING SOLUTION

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Abstract. The article considers and presents the classification methods of identifying and assessing petroleum biological contamination and techniques in maintaining biological stability of hydrocarbon fuel. The article focuses on analysis, arrangement and classification of the methods for identifying petroleum biological contamination and maintaining microbiological stability of hydrocarbon fuels.

Keywords: aviation fuel, biological pollution, express-method, biological stability, additive.

1. Introduction

The number of various transport facilities used in Europe is rapidly growing. They release a large amount of pollutants into the atmosphere. Therefore, environment protection from the pollutants ejected by internal combustion engines is a key problem recently facing us and will remain a burning issue in the future. Biofuel is the only effective and widely used alternative fuel that can reduce environmental pollution. The main aim of research by Lingaitis and Pukalskas (2008) is to perform a comparative analysis of the burnt gases of the engines using rapeseed oil methyl ester and petroleum diesel oil and to determine the ecological effectiveness of biofuel used in diesel locomotive engines in railway transport.

The problems of implementing liquefied petroleum gas (LPG) supply systems are related with the fact that they are alternative systems used in the engines constructed and optimized for work with other kinds of fuel. Thus, the assemblers of the systems have to simultaneously evaluate power losses and ecological requirements. The experiment focuses on analyzing the gas composition of the engines working at different modes in order to specify the particularity of LPG system tuning and to obtain data required for evaluating environmental pollution by numerical car dynamics models. It is estimated that the algorithms of the current LPG systems balance between ecological requirements and optimization of the external characteristics of engines and the gas systems are characterized by a great inertia. Moreover, it is determined that more precise tuning algorithms must be constructed as well as more tuning points and tuning itself made in the standard modes of engine work must be foreseen (Mockus *et al.* 2006).

The aim of research by Tanczos and Torok (2007) is to prove the connection between CO_2 emission and climate change and to estimate the CO_2 emission of the transport sector in Hungary. Researchers have to clarify the emission of the transport sector in order to get information on externalities, which is a further step toward a sustainable society. Sustainable development is a process where the pace of technical development, the satiation of increasing supply and the raw materials and resources of Earth are poised so that the rate of living and the opportunities of the next generations need not be worse. One of the most emphasized goals of the transport policy of the European Union is sustainable mobility. For this reason transportation systems must be developed and standardized, the effectiveness of transportation services must be increased while the environmental pollution must be decreased or prevented. Decoupling motorization from environmental pollution is a task for engineers whereas the increase of economical activity from mobility is a task for economists.

By Butkus *et al.* (2007), Lithuania's accession to the EU has revealed that it is very important to use a larger amount of renewable fuel. Based on economic and environmental considerations in Lithuania, the authors are interested in studying the effects of turpentine contents in the blended turpentine–diesel fuel on the engine per-

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formance and pollutant emission of compression ignition engine. The tests on an engine dynamometer of the car Audi 1Z and tractor D21 diesel engines were carried out in the laboratory. The experimental results showed that turpentine used in the fuel blend for the above introduced diesel engines had a positive impact on engine performance and exhaust emission.

Pollution is a major problem in all countries including the developed ones (Vaitiekūnas and Banaitytė 2007). It is a major environmental negative impact of anthropogenic activities affecting ecology. There are two effective ways of assessing a negative impact of motor transport flow intensity and pollution level: monitoring the air and modeling pollutant dispersion. It is very important to estimate different unknown air modeling programs. Research by Vaitiekūnas and Banaitytė (2007) discloses that modeling is to be executed by the US EPA (United States Environmental Protection Agency) the so-called 'the best possible existing software for strategic environmental assessment' which is also recommended by the Ministry of Environment of the Republic of Lithuania. Researchers' work uncovers that pollution modeling was executed for the northern part of Vilnius (Lithuania). The main target was to evaluate pollutant dispersion from motor transport in the analysed area of Vilnius. A maximum of hourly, daily and annual concentrations of carbon monoxide, nitrogen oxide, sulphur dioxide, volatile organic compounds and particulate matter were observed during investigation.

Investigations have shown that ammonia oxidation is not inhibited by diesel fuel in a soil with a long history of contamination contrary to a non-contaminated soil. As a consequence, ammonia oxidation does not constitute a limited step in the nitrification process. Moreover, this type of soil has also had the opportunity to develop an abundant microbial population able to metabolise the diesel hydrocarbons. The situation whether the properties of soil with a long history of diesel fuel contamination may affect the activity of nitrite-oxidising bacteria was investigated. It was observed that the re-exposure of soil to diesel fuel apparently stimulated the proliferation of nitrite-oxidising bacteria, as determined by the most probable number (MPN) culture technique and MPN-polymerase chain reaction technique. The potential of nitrite-oxidising activity in soil treated with diesel fuel was about 4 times higher than that in the control without addition. In the presence of diesel fuel and ammonium, the potential nitrite-oxidising activity was 40% higher than that in the presence of ammonium only. However, in the presence of hydrocarbon only, a low proliferation of Nitrobacter was observed, probably because the heterotrophic bacteria were strongly limited by lack of nitrogen and did not produce sufficient organic metabolites that could be used by the Nitrobacter cells (Deni and Penninckx 2004).

Microbiological pollution, by Boychenko (Бойченко 2001), can be present in motor fuel. Pollution can occur during the period of storage, transportation or direct use. The energy sources of the air-feed jet engines are the types of fuel especially vulnerable to microorganisms.

Fuel pollution, first of all, depends on the level of the technological culture of using them. A constant use of polluted fuel can result in serious consequences.

Biomass blocks filters and fuel pipe results in the underpressure of fuel and lubricating materials, metal corrosion and can cause failures. Therefore, it is very important to uncover the reasons for fuel biopollution and to prevent from spreading them out.

The article focuses on analysis, arrangement and classification of the methods for identifying petroleum biological contamination and maintaining microbiological stability of hydrocarbon fuels. Analogical researches are presented by Litvinenko (Литвиненко 1977) and Boychenko (Бойченко 2001).

2. Research

All methods for identifying fuel microbiological contamination can be divided into long and express-methods (Fig. 1) whereas the methods enhancing microbiological stability of fuel are divided into physical-mechanical and chemical ones (Fig. 2).

Nowadays, there is no standard way of defining the microorganisms causing fuel pollution; therefore the same methods used for mediums with a mix of liquid hydrocarbons are applied. As a rule, it is necessary to take into account the quantity of the formed biomass or the number of the crates of the microorganisms. However, it can be hardly performed due to the presence of two stages in the medium as the microorganisms are partially placed not only in water but also in a hydrocarbon phase, see research by Grechushkina *et al.* (Гречушкина *et al.* 1980).

The method of a direct calculation of the number of the crates under the microscope to define the number of the microorganisms in the medium with liquid hydrocarbon or petroleum is very rarely used mostly because of emulsion presence and non-uniform distribution of the crates in the medium. Besides, among the microorganisms contaminating petroleum fuel, there are a lot of fine forms (representatives of Mycobacterium, Pseudomonas etc.). Thus, no possibility of counting them up in accounting chambers exists.

The method of counting the microorganisms on the fixed painted smear is also poorly adapted for the cultures growing on mediums with hydrocarbons as emulsion is not distributed at regular intervals on subject glass and to prepare a certain area is not always possible. Nevertheless, if water fraction is considerable enough and the fuel does not mix up, this method can be used to define the number of bacteria in a water layer.

The method of a direct calculation of the microorganisms under the microscope enables to define the number of the microorganisms in the substrate more precisely but do not permit to distinguish between dead and alive microorganisms.

Therefore, an analysis of fuel and 'water pillows' frequently uses the method of counting the microorganisms grown on rich mediums which permits not only to determine the quantity of the alive crates in substrate but also to estimate a variety of microorganisms (on the

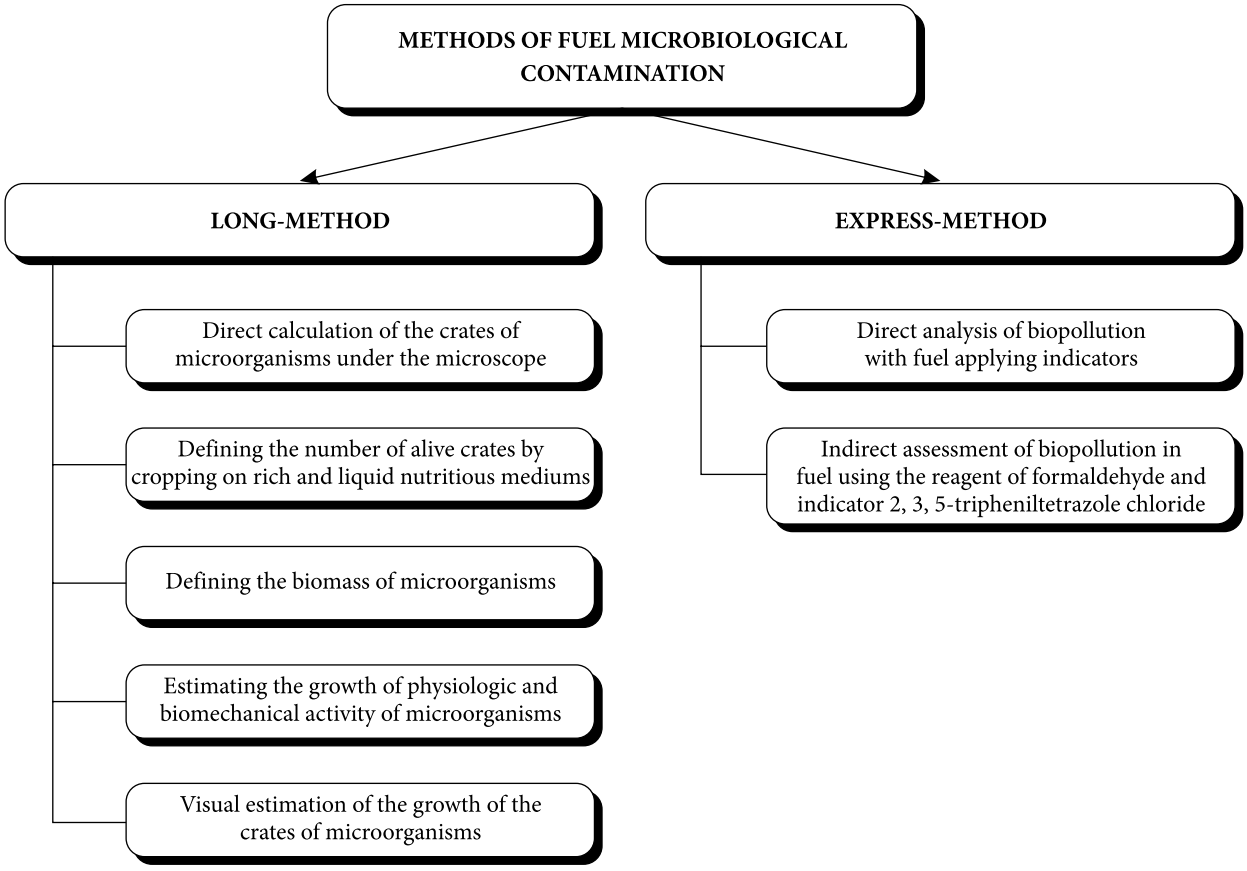

Fig. 1. The generalized classification of the methods assessing petroleum biological contamination

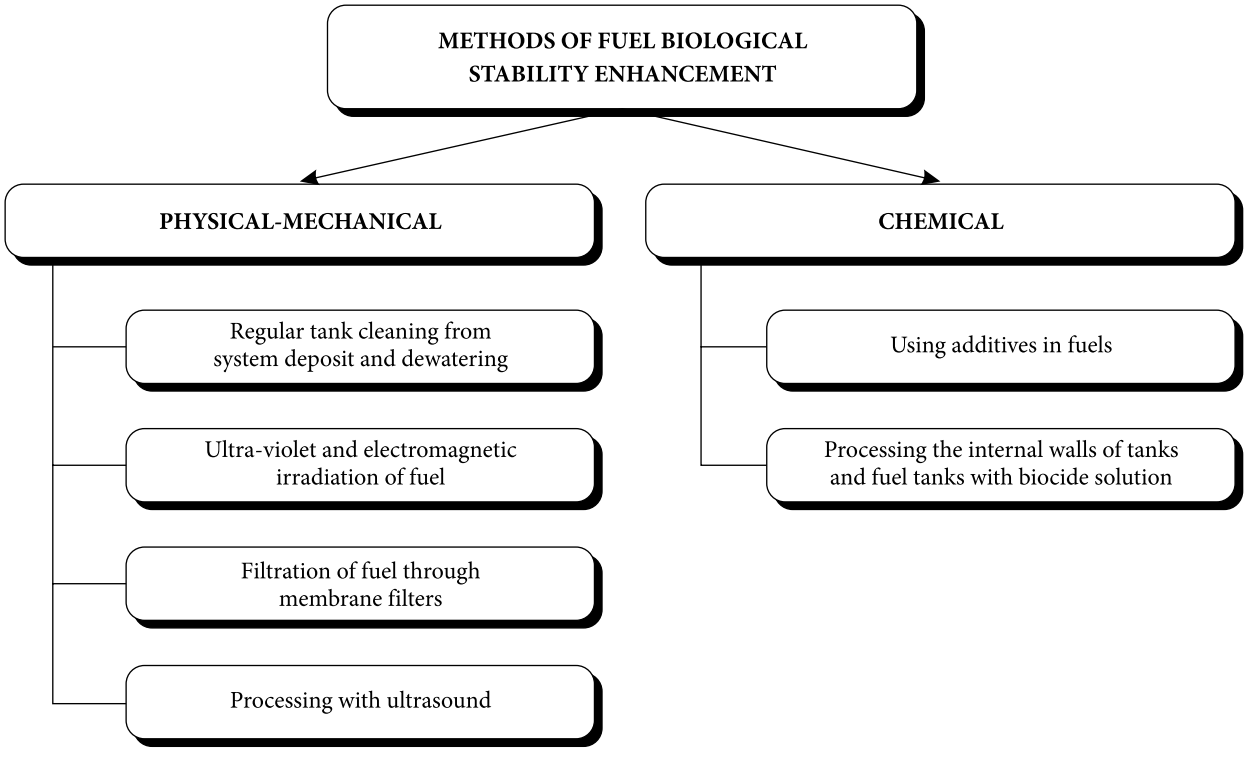

Fig. 2. Classification of the methods enhancing biological stability of fuel

morphology of colonies). In most cases it is necessary to use the nutrient mediums of various structures enabling to determine a wider spectrum of microorganisms referred to different physiological groups.

The method of defining the number of the microorganisms by cropping on rich mediums gives the important information on a variety and change of the quantity of the viable forms in research substrate. However, an essential disadvantage of the method is the distribution of the microbe crates in both phases including water and fuel which does not give an opportunity to prepare the exact mix and to lead a quantitative crop. The microflora of each phase has to be considered separately, and therefore this method is suitable basically for research purposes but is inconvenient for mass tests. However, sometimes it is used to check the impact of biocide on fuel. See research by Krasilnikov (Красильников 1966).

For calculating the quantity of viable microorganisms in different emulsion including the mixes of petroleum with water, it is recommended to apply an express-method with immersion glass. The method is convenient as there is no need to investigate different phases in mixes or to achieve uniformity which is not always possible. Besides, it is distinguished by speed, easiness of execution and its resolution permits to determine the number of the viable forms in emulsion in the range from $1 \cdot 10^3$ up to $1 \cdot 10^5$ crates in 1 ml, see research by Rabotnova *et al.* (Работнова *et al.* 1973). The technique is based on the classical method of bio-fouling glass lays and is applied to study soil microorganisms.

The control of microorganisms development in the water-fuel systems is established not only by counting the number of biomass crates, but also by tracing changes they can cause in the environment. Such a campaign of petroleum bio-contamination is rather expedient as changes in substrate do not always correlate with the quantity of the formed biomass. Changes in the parameters of substrate quality are frequently insignificant in the process of an active development of the microorganisms while certain low contents of the microorganisms can result in irreversible damage to petroleum.

The functions of the microorganisms can be studied by the consumption of the components found in an environment, the allocation of vital activity products and changes in substrate physics-chemical parameters (viscosity, greasing properties, emulsification and acidity). Such control supposes the necessity conducting special researches to reveal microflora and to study its physiologic-biochemical attributes. The development of the microorganisms can also be estimated by the consumption of nitrogen from the environment. It is known that the deoxidizing agents easily determined by appropriate indicators can be allocated into environment by a number of microorganisms. By identifying the degree of changes in colours, it is possible to assess the content of bacteria in the substrate. Fast control of bacteria quantity in oils and fuels is established using indicators 2, 3, 5-threephenil tetrazole chloride (TTCH) which turns into an insoluble red pigment formazone at presence of deoxidizing agents. The methods of defining the content of bacteria in substrate using TTCH is referred to the express-methods – the results are registered some hours later mixing the reagent.

An important scientific-applied problem is a protection of hydrocarbon fuels from microbiological contamination.

One of the simplest methods of preventing microbiological contamination is correct technical supervision for the technological processes of petroleum use as the degree of polluting fuel with the microorganisms depends first of all on the accurate fuel handling and maintaining the communications of tanks and fuel systems as well as on their dewatering.

The methods of ultra-violet and electromagnetic irradiation are developed. The ultra-violet irradiation causes the destruction of the microorganisms.

The destruction of the microorganisms is also possible under the influence of electromagnetic irradiation at certain frequency of radio waves.

The colonies of mushrooms and bacteria are allocated with filtration through porous material the pore of which makes 2 microns. The way of fuel protection using bacterial filters is possible. The filters can be produced from cotton, glass and synthetic rubber filled with silver connections.

There are many updatings and combinations of different methods. However, they are not popular enough due to various disadvantages. The use of these methods is frequently rather labour-consuming, for example, dewatering. Some physical methods are hard for introducing (ultrafine filtration) or they are unsafe for the attendants (radio waves and electromagnetic processing). Thermal processing can result in the deterioration of fuel operational characteristics. The main disadvantage of these methods is that they are designed for destructing the microorganisms in the given moment and do not exclude their subsequent contamination. Except from low efficiency, these methods differ significantly on the cost of introducing them. These problems are investigated by Krein *et al.* (Крейн *et al.* 1969).

A modern efficient way of protecting fuels from biological pollution is biocide additive. They oppress vital activity of the microorganisms in jet fuels and prevent from biological corrosion of fuel tanks (Егоров *et al.* 1978). The generalized assortment of biocide additive is shown in Table.

3. Conclusions

This study of the existing methods of assessing biological contamination has allowed us to formulate a conclusion that the dominating methods are long and their main disadvantages are complexity and labour-intensiveness.

Today, the most important requirements for the methods assessing and forecasting any parameters or properties are as follows: reliability and reproducibility, sensitivity to changing properties, accuracy, simplicity and universality.

The world tendency towards developing the assessment methods and properties of forecasting petrochemicals is characterized by the complex association of the

Assortment of biocide additive

Additive	Concentration, %
Ethylene glycole monomethyl ether(FS2)	0.100–0.150
Biofore F	0.100–0.150
Dimethyldialkil-ammoniumchloride	0.050
Dimethylalkilbenzyl-ammoniumchloride	0.050
PFA-55 MB	0.050–0.150
Disalicylidepropanediamine	0.100
Salts of zinc of synthetic fatty acid. Mixed salts of zinc and mercury of acetic and oleic acid	0.050–0.100
Bactericidal additive	0.100
BIOCONTROL MAR-71	0.300
Wynn's fuel biocide	0.100
Katon FP 1.5	0.015–0.0300

listed requirements with a significant reduction of time necessary for a single analysis.

Therefore, the most perspective methods are the express-methods the crucially important one of which is the express-definition of biological pollution with jet fuels.

The quality of fuels is directly connected with the safety of flights.

The operative definition of jet fuel quality by the content of particles and water and the presence of biomass are the most important issues of assessing the quality of air combustive-lubricating materials under lab conditions.

For this purpose, it is expedient to develop a fast and effective express-method of testing the biological contamination of jet fuels using the indicator.

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