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DETERMINATION OF IMPURITIES IN BIOFUELS WITH USING A PARTICLE SIZE ANALYZER

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Abstract

VALACH MICHAL, MAREČEK JAN, HLAVÁČOVÁ ZUZANA, TRÁVNÍČEK PETR, GLOS JOSEF: *Determination of impurities in biofuels with use of particle size analyzer.* Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, 2013, LXI, No. 3, pp. 813–817

One of the qualitative parameter of biofuel is purity. Measurement of purity of biofuels is very important. The reason is that the number and size of particles influence an engine life. However number and size of various particles have influence on the hydrodynamics and rheologic properties. In the first part of the paper is introduced the description of tested fuels, the method of measuring of number particles and size particles with use particle size analyzer Laser-Net Fines-C (LNF-C). In the second part of this paper results of measurements are stated. The results are compared and evaluated. Two kinds of fuels was tested – biofuels and traditional fuels. Pure rapeseed methyl ester and various mixtures of traditional diesels and rapeseed methyl ester represented Biofuels. Bioethanol was the next tested biofuels. Traditional diesels were the second group of tested fuels.

particle analyses, particle counter, purity of biofuels

Impurities in biofuels have the origin in several sources. At first it is mechanical impurities (dust, abrasion) or products of chemical degradation of biofuels. If biofuels have high content of impurities, combustion process in an engine has worse running. The change of hydrodynamic behaviour of fuels or the change of rheological properties can be consequence too. In case that this factors concatenate, failure or accident of an engine an arise soon. The state of cleanliness in process can be monitored by detailed, accurate and periodic analysis of impurities in biofuels. For this purpose must be used simple device, which is not demanding in operation or maintenance. And samples need not complicated preparation. Impurities in biofuels are all foreign substances such as gases, liquids or solid particles. Sources of impurities are separated to four basic groups. Various complicated and exact methods we use for demanding of impurities total content. These methods are gravimetric method (filtering and weighing on the membrane filter), curing method and subsequent weighing, method of counting particles, which are collected on the filter with using of an automated optical microscope or method with using automatic particle counter. Currently liquid biofuels are often discussed topic. But most of professional papers discuss topics on the theme of emissions, which are generated during biofuels combustion, their impact on the environment (Gasparatos *et al.*, 2011; Acquaye *et al.*, 2012; Liaquat *et al.*, 2010) or problematic of biofuels production (Nigama *et al.*, 2011). Currently purity of biofuels is not often discussed topic. The aim of this work is evaluation of purity and free water of selected liquid fuels sample with using of automatic laser particle counter and classifier Laser-Net Fines-C (LNF-C) and their comparing.

MATERIALS AND METHODS

Samples

For the purpose of the paper were used biofuels on the base of bioethanol and on the base of rapeseed methyl ester from various Slovak refineries. Samples, the base on of rapeseed methyl ester, were following: Biodiesel S and Biodiesel MB. These fuels are mixtures rapeseed methyl ester and diesel oil. The next sample marked MERO was pure rapeseed methyl ester. The sample E85 was fuel, based of bioethanol (the mixture of 85 % bioethanols and 15 % petrol). The last alternative fuel was researched Sunflower Oil, which is sporadically used in agriculture sector but also in the transport. Samples Diesel 6.5, Diesel 6.2 and Diesel 0 were control samples. These are diesel oils blended with 6.5 % of rapeseed methyl ester, 6.2 % of rapeseed methyl ester and diesel oil without additives.

Particle Size Analyzer

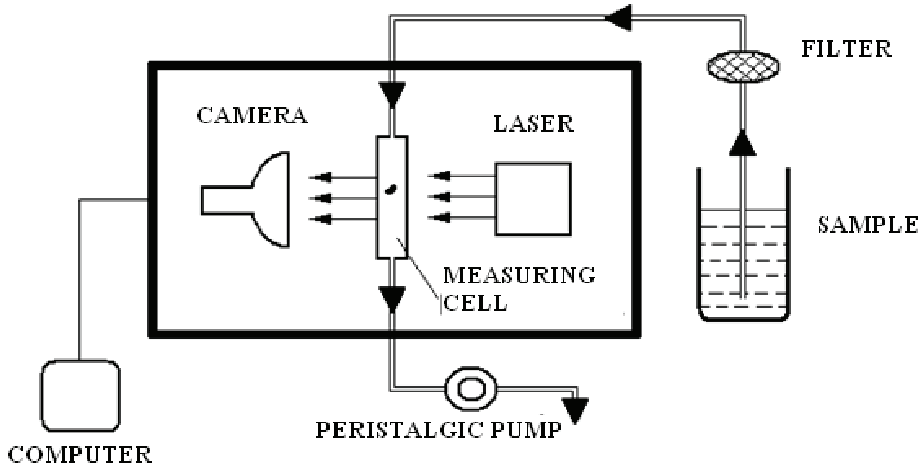
For the purpose of the paper particle size analyzer Laser-Net Fines-C (Spectro Inc., USA) was used. The analyser can be used for analysis of fuels, biofuels and oils from various equipments. The results of analysis are amount of particles, particle size and analysis of abnormal wear particles. The measuring device analyses all particles to the size of 100 µm. The volume of samples was 5–15 ml. The volume of a researched sample depends on the viscosity and degree of accuracy. Used particle size analyser Laser-Net Fines-C is showed in the Fig. 2.

The sample after preparation is pumped by peristaltic pump throughout microten filter to the glass cell. The pulsed laser passes throughout of the glass cell. Rays of the laser impact on the background, which is shooted by a CCD (Charge-Coupled Device) camera. This camera catches siluets of particles. The image is digitalized and processed by software. The scheme of the basic principle of Laser-Net Fines-C is showed in the Fig. 3.

The numbers of particles were counted according to technical standard USA: ISO 4406, NAS 1638, NAVAR 01-1A.17, SAE AS 4059. Afterwards the free water was determined. The calibration of the device was performed with use of calibration fluid ISO MTD 2.8 mg·l^{-1}. All

1: *Selected samples: 1 – E85, 2 – MERO, 3 – Sunflower Oil, 4 – Biodiesel 6.2, 5 – Biodiesel 6.5*

2: *Particle Size Analyzer Laser-Net Fines-C*



3: *The basic principle of the measuring device Laser-Net Fines-C*

I: *Particle size distribution of biofuels and free water*

Sample	Numbers of particles				Free Water [mg·kg⁻¹]
	> 4 µm	> 6 µm	> 14 µm	> 20 µm	
E85	1 274	519	11	70	-
Biodiesel S	1 066	413	70	50	-
MERO	12 511	4 832	2 020	1 564	8.6
Biodiesel MB	23 956	1 732	66	46	-
Sunflower oil	4 088	1 286	253	131	-

II: *Particle size distribution of traditional fuels*

Samples	Numbers of particles				Free Water [mg·kg⁻¹]
	> 4 µm	> 6 µm	> 14 µm	> 20 µm	
Diesel 0	510	171	44	26	-
Diesel 6.2	245	75	7	7	-
Diesel 6.5	177 381	7 601	91	91	-

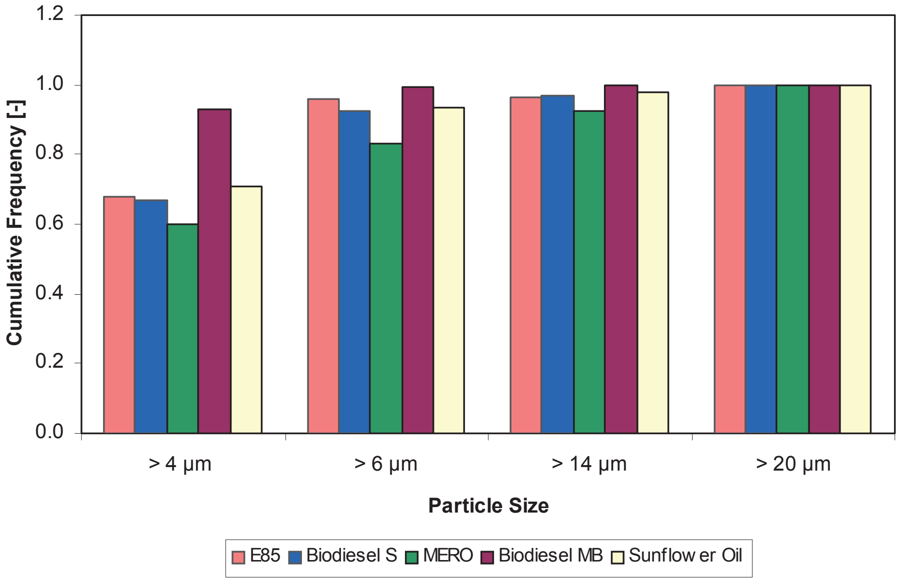
measurements were performed at temperature 20 ± 1 °C. Numbers of particles were counted for 1 m·l^{-1}.

RESULTS AND DISCUSSION

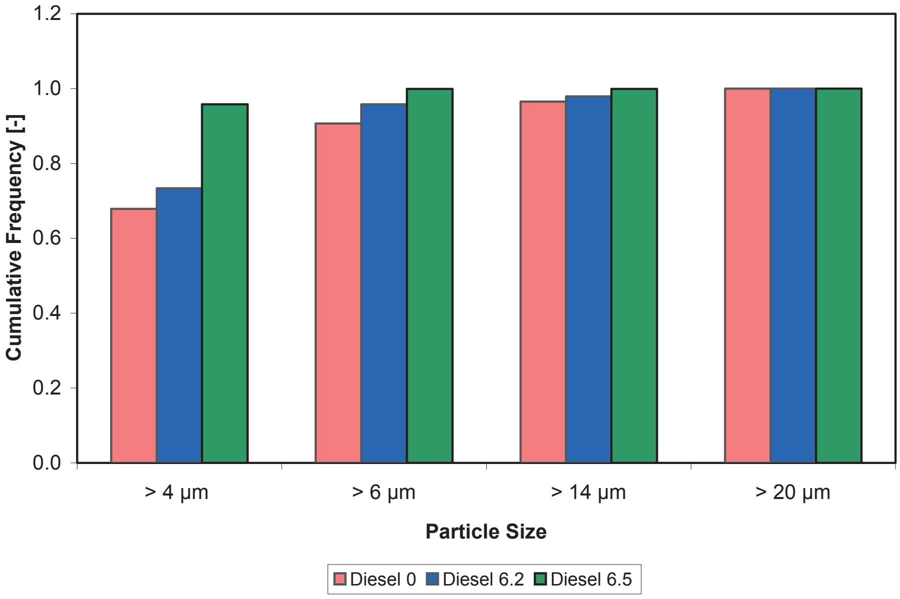
In the Tab. I results of measurements of biofuels are showed. Values of impurities are divided to four fraction: > 4 µm, > 6 µm, > 14 µm, > 20 µm. Further value of free water was measured. These values are also given in the Tab. I. From the table is evident that sample Biodiesel has the highest number of particles in the fraction > 4 µm. The sample MERO has the highest number of particles in all other fractions, i. e. > 6 µm, > 14 µm and > 20 µm. This sample contained also free water. Other samples did not contain any free water. A content of free water in the fuel is undesirable phenomenon, because water can cause rust of engine parts. This process can be accelerated by acids and hydroperoxides during oxidation of fuel (Graboski *et al.*, 1998). A content of free water is also dependent at temperature (Farahani *et al.*, 2011). In according to Farahani free water content reaches the value 0.03 mg·kg^{-1} at temperature 20 °C (Farahani, 2011). However in according to Chuck (2012) the sample of methyl ester can reach the value of free water 210 mg·kg^{-1} (Chuck *et al.*, 2012).

In the Tab. II measured values of traditional diesels are showed. These diesels are commonly sold at the petrol station. Tested samples Diesel 0 and Diesel 6.2 have very low number of particles. But somewhat surprisingly the sample Diesel 6.5 has very high number of particles in all fractions. In the fraction > 4 µm has even 177 381 particles in tested sample.

When comparing obtained results of biofuels and traditional fuels, we can found, that the sample Diesel 0 was with the least of number of particles in all fractions. Contrarily the sample Diesel 6.5 had the highest number of particle in fractions > 4 µm and > 6 µm and the sample MERO had the highest number of particles in fractions > 14 µm and > 20 µm. The number of particles in the sample Diesel 6.5 is surprisingly high and it is probably caused



4: *Cumulative frequency of biofuels*



5: *Cumulative frequency of traditional diesels*

by degradation of bio-components in diesel. The measurement also proved that purity of biofuels is comparable with purity of traditional fuels. Generally the number of particle in biofuels is low in the comparison with different operating fluids. As an example may be mentioned motor oil Ursa Super (20W/50) from engine UTD-20, which is operated by Czech army. In this fluid the number of particles was 43 170 in the fraction > 4 µm, 1 370 in the fraction > 6 µm and 2 491 in the fraction > 14 µm (Glos, 2011).

Cumulative frequency of biofuels and traditional fuels area showed in the Fig. 4 and Fig. 5. From figures is evident, that rate of impurities size 4 µm and higher is about 60% from the suma of all particles. Sample Biodiesel MB (Fig. 4) a sample Diesel 6.5 (Fig. 5) is exceptions, because there is rate more than 90%.

SUMMARY

The device LNF-C is very effective tool for demanding of biofuels cleanness. The advantage of this method is quick and easy preparation of samples. The next advantage is exclusion of the subjectivity during evaluating of type and seriousness of impurity. Very exact information about real impurity of

biofuels is possible to obtain by combination of several types of methods for evaluating of cleanness. Detailed analysis of impurities performs in case of abnormal development trend. Using of automatic particle counter with other methods (atomic emission spectrometry, infrared spectrometry) is the way for effective observation and evaluating fuels.

Purity of measured biofuels samples is high and it is very similar as purity of traditional diesel. It is especially true for samples E85 and Biodiesel S. The exception between traditional diesels was the sample "Diesel 6.5". But there is a probability that biocomponents in this sample were degraded. Biofuels are very purity as comparison by different operating liquid, such as motor oil. In the test was observed fraction > 4 μm, > 6 μm, > 14 μm, > 20 μm. Generally sample Diesel 6.5 had the highest number of particle in fractions > 4 μm and > 6 μm. The sample with the second highest of particles number was MERO. The sample MERO had the highest number of particles in the fractions > 14 μm and > 20 μm. Free water was found only in the sample MERO.

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