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THE PHYSIOCHEMICAL AND ECOLOGICAL PROPERTIES OF DIESEL OILS

Key words: liquid fuels, diesel, physiochemical properties.

Abstract: The article presents the results of the physiochemical properties of diesel samples acquired in 2014-2016 while taking into account the requirements specified in PN-EN 590: 2013 European Standard. The study was conducted in cooperation with oil producers and suppliers from Masovian Voivodeship. Research shows that the most commonly exceeded parameter of diesel oils were water and sulphur contents. The results allowed for the assessment of the quality of the fuels and were the basis for their release into the market. Thorough examination of the fuels results in a better overall quality of this product available on the market through reduction of possible violations.

Właściwości fizykochemiczne i ekologiczne olejów napędowych

Słowa kluczowe: paliwa ciekłe, oleje napędowe, właściwości fizykochemiczne.

Streszczenie: W artykule przedstawiono wyniki badań właściwości fizykochemicznych próbek olejów napędowych z uwzględnieniem obowiązującej w tym zakresie normy PN-EN 590: 2013. Badania przeprowadzono w latach 2014 – 2016 przy współpracy firm paliwowych z województwa mazowieckiego. Z badań wynika, że najczęściej przekraczanymi parametrami były zawartość wody i zawartość siarki. Uzyskane wyniki pozwoliły na ocenę jakości badanych paliw i równocześnie stanowiły podstawę dopuszczenia ich do obrotu, co prowadzić powinno do zmniejszenia nieprawidłowości.

Introduction

Diesel fuels are the mixture of several fractions obtained from crude oil processing [1–3]. The proper quality of the fuel influences the following issues: the proper combustion (the ability to self-ignition), the formation of the proper air-fuel mixture, and the easy start of the engine under various temperature conditions. Their chemical properties should not cause corrosion, sediments, or the intensification of wear. Constantly growing ecological requirements limits the smoke level as well as the concentration of harmful substances in exhausts.

Issues concerning the possibility of the reduction environmental risks caused by internal combustion engines are described in numerous papers [4–7]. Some findings in this field have been made by a number of national and international organizations, such as the EPA (Environmental Protection Agency), ACEA (European Automobile Manufacturers Association), the ECE (Economic Commission for Europe), POPiHN (Polish Organization of Oil Industry and Trade), and others. For the reduction of environmental pollution, it is important to deploy modern combustion systems, technical solutions in diesel engines aimed at better combustion efficiency as well as by the proper composition of the fuel. The change of fuel properties depends on the limitation of sulphur and aromatic content and proper blending. The fuels may be supplemented by additives reducing the production of soot and hydrocarbon by-products.

Physical and chemical properties and test methods for diesel fuels determine the European Standard PN-EN 590: 2013 also applied in Poland. In 2004, Poland deployed the official system for liquid fuel quality monitoring. Unfortunately, in many cases, this system is insufficient due the random sampling [8–15]. In practice, the commercially available fuels can have very different properties. Therefore, there is a need to determine the actual nature of the ordered batches of fuel and this applies particularly to the small companies in the fuel market.

The aim of the study was to analyse the quality of diesel fuels sold to wholesalers operating in the Masovian Voivodeship, according to the PN-EN 590: 2013 European Standard.

1. Materials and methods

In cooperation with wholesalers acquiring oils from different suppliers, 167 samples of these fuels were investigated. The following parameters were analysed: viscosity, density, water content, sulphur content, flash point, fractional composition, and the strip corrosion of copper. Tests were performed according to PN–EN 590: 2013 European Standard using the following specialized and equipment:

– Viscometer HVU 481 by Herzog,
– Oscillating densitometer DM 4500 by Anton Paar,
– Karl Fischer apparatus Titrando 851 equipped with the water evaporation oven Compact Oven S.C. 885 by Metrohm,
– Sulphur content analyser, dedicated for petroleum products Sindie 7039 by XOS,
– The apparatus for determination of the flash point in closed cup Pensky Martens by Walter Herzog,
– The apparatus for the determination of the fractional composition of petroleum products by normal distillation by Walter Herzog, and
– Set for the corrosion intensity assessment against copper by ITeE – PIB.

The viscosity of the fuel has a big impact on the flow through the supply system and piping and on the course of atomization and evaporation of the fuel in the combustion chambers. It also protects cooperating parts against excessive friction and wear.

The density of the fuel depends on the group composition. The knowledge of density allows for quick differentiation of particular fuel grades. It is an indicator of the amount released when the fuel is distributed.

Water enhances the wear of the fuel supply system and piping, and under low temperatures, it may produce crystals and thus block the filters and pipes.

Sulphur influences the corrosion of engine components and the emission of toxic compounds into the atmosphere. The material most susceptible to corrosion caused by sulphur is copper and its alloys.

Flash point characterizes the ability of the fuel vapours to ignite under the ambient conditions. This parameter is analysed mainly to assess fire safety. On its basis, the volatile contaminants or post-production residues in the fuel may be detected.

The fractional composition determines the fuel's ability to create a mixture that properly ignites. It is defined by distillation, giving the percentage of distilled fraction for a certain temperature, e.g., 250ºC – less than 65% vol., 350ºC – more than 85% vol., and the temperature to distil 95% vol. (heavy fractions) – below 360ºC. Determination of fractional composition also allows for the identification of the fuel.

The study was performer in the period 2014–2016. The results are presented in Figures 1–3. The figures also specify the limits according to the PN-EN 590: 2013 European Standard.

2. Results and discussion

The analysis of the results indicated that the viscosity of the fuels were at acceptable levels between 2.1 to 4.4 mm^2/s. Slightly worse results were recorded for the density. The density is generally within the range of 821 to 844 kg/m^3, which was in accordance with the norm. An exception was the one sample, which had a density of 860 kg/m^3 (by the upper acceptable level of 845 kg/m^3). The water content of a substantial part of the samples was consistent with the requirements. However, in 2014 (8 samples) and 2015 (2 samples), this parameter was below the normative recommendations of 200 ppm. Most of the samples were characterized by a proper ignition temperature, which was generally above 55ºC. Two tested samples showed a decreased ignition temperature of 50ºC. The other 11 samples had excessive sulphur contents that were more than normative 10 ppm. The sulphur content in the mentioned samples was in the range 11–50 ppm. One of these samples also contained a significant amount of water. However, all the tested samples were evaluated as grade 1 for their corrosiveness to copper. The research also showed that three samples did not meet the requirements for fractional composition. One of them did not distil at 350ºC. In the case of another sample, the distillate content at a temperature of 350ºC was too low in comparison to the reference diesel oil. The distillation curve for that sample is shown in Fig. 4. For other sample, the distilling temperature was recorded as too high to distil 95 % of the volume. The fractional compositions of the remaining samples were in-line with the requirements. The distillate content at 250ºC was 20 to 64 vol. %, whereas at 350ºC, it was between 88 and 99 vol. %. The temperature required to distil 95 vol. % of the fuel was between 330 and 360ºC. An example of the distillation curve of the sample meeting all the specified normative requirements is shown in Fig. 5.

Fig. 1. Physiochemical properties of fuel samples acquired in 2014

Fig. 2. Physiochemical properties of fuel samples acquired in 2015

Fig. 3. Physiochemical properties of fuel samples acquired in 2016

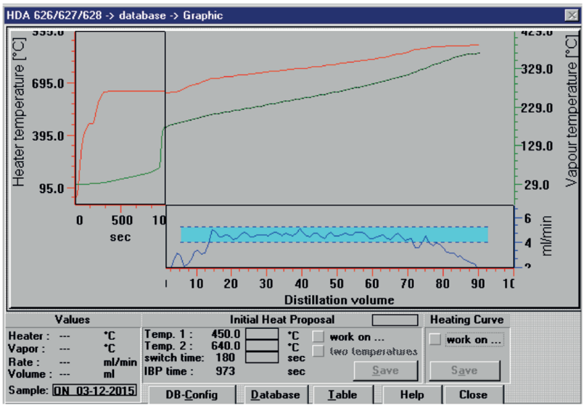

Fig. 4. The distillation curve of the fuel with improper fractional composition

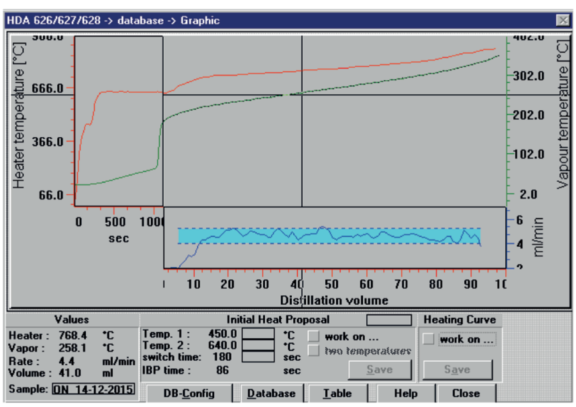

Fig. 5. The distillation curve of the fuel with adequate fractional composition

These data indicate the possibility to use the mentioned analyses to assess fuel quality. Most of the tested fuels met all the requirements, especially in terms of viscosity and corrosiveness to copper. All the recorded improprieties concerned the water and sulphur contents. The reason for such discrepancies was probably insufficient protection against hydration, contamination, or mixing with other materials

Conclusions

The constantly increasing stringency of environmental protection requirements urges research to seek effective solutions to improve the performance characteristics of fuels for internal combustion engines. The results of the presented research confirm the need for the testing of physiochemical properties of fuels placed on the market in order to assess their quality. The knowledge of the characteristics of the fuel allows for the elimination of the suspected supply chains and thereby the problems associated with the use of defective fuel (excessive pollution, engine damage, etc.). Any detected abnormalities in fuel quality and potential financial consequences are the best motivating factors for keeping the standards by the suppliers.

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