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# Abstract

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Diesel oil is mainly known for being a very popular fuel used in compression-ignition engines installed in various types of vehicles. Its popularity is evidenced by its consumption, which amounted to 18.191 million tonnes in Poland in 2021. In comparison, the consumption of petrol (95 and 98 combined) was 4.846 million tonnes and that of liquefied petroleum gas (LPG) was 2.441 million tonnes. In the European Union, there has been an increase in diesel consumption over recent years, which may not be entirely obvious given the increasing number of vehicles powered by so-called renewable energy sources.

Modern diesel engines have become much more fuel-efficient mainly due to direct injection systems. Reducing its consumption while improving combustion quality is the result of precise timing, i.e. the moment of injection, as well as the amount of fuel injected under high pressure. The injectors produced today are therefore high-precision, expensive devices and are unfortunately sensitive to any contamination. Water is regarded as one of the main contaminants in diesel fuel and can cause serious damage to the injection system. These significant improvements in the performance of diesel engines would not be possible without simultaneous improvements in fuel quality.

Any commercially available fuel in Poland must meet the requirements of the Regulation of the Minister of Economy of 9 October 2015 on quality requirements for liquid fuels (Journal of Laws 2015, item 1680). It describes a number of parameters, including the permissible water content of 200 mg/kg in diesel fuel. Despite the low solubility of water in diesel and a number of procedures developed and required by standards, it happens that the water content of fuel exceeds the permissible value. Reports from the (Polish) Office of Competition and Consumer Protection on fuel quality inspections between 2013–2021 showed up to several exceedances per year in diesel alone. Less than a thousand samples taken from various locations and entities were tested each time. Remarkably – exceedances of the permissible water content in diesel even occurred at fuel wholesalers.

The method currently used to test the water content of diesel fuels is based on Karl

Fischer coulometric titration. It is an extremely precise method, but requires qualified personnel able to operate specialised laboratory measuring equipment. Chemical reagents are also required to perform the measurement. Mainly for this reason, it is not used at the inspection site, e.g. at the petrol station.

This dissertation attempts to demonstrate that it is possible to detect exceedances of the permitted water content in diesel fuel using impedance spectroscopy. The impedance spectroscopy method can be implemented in a portable device, the operation of which need not be complicated. Hence, the research results shown in this work may open the way to the construction of an apparatus that could be used in the future at the location of initial diesel quality control. Such a portable measuring system could be relatively inexpensive and could be used for preliminary assessment of fuel quality in terms of water content. The relatively low cost and ease of use could contribute to an increase in the number of inspections and ultimately improve the quality of available fuel.

The dissertation discusses diesel fuel and the impedance spectroscopy method. The results of diesel fuel tests carried out by the author using a laboratory-based commercial electrochemical impedance spectroscopy measurement system are presented. The test material consisted of retail available summer, winter, regular and premium oils doped with a known measured amount of water. An electric equivalent circuit for diesel oils, one of whose parameters varies significantly as a function of the amount of water, is proposed. A procedure is also presented that allows the water content of the fuel under study to be estimated from impedance spectroscopy measurements. The effects of verifying the findings obtained in the form of test results for other oils similar in their properties to diesel fuel are also shown.