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Impact of using automotive Diesel fuel adulterated with heating Diesel on the performance of a stationary Diesel engine

S. Kalligeros [a,*], F. Zannikos [b], S. Stournas [b], E. Lois [b], G. Anastopoulos [b]

[a] *Elinoil S.A, Research and Development Department, 33 Pigon Street, Athens 145 64, Greece*

[b] *National Technical University of Athens, School of Chemical Engineering, Iroon Polytechniou 9, Athens 157 80, Greece*

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Abstract

Air quality improvement, especially in urban areas, is one of the major concerns. For this reason, car and equipment manufacturers and refiners have been exploring various avenues to comply with the increasingly severe anti-pollution requirements. Adulteration of fuels stands as a roadblock to this improvement. In this paper, fuel consumption, particulate matter and exhaust emission measurements from a single cylinder, stationary Diesel engine are presented. The engine was fuelled with automotive Diesel fuel, which was adulterated with domestic heating Diesel in proportions up to 100%. The four types of adulterated Diesel fuel investigated increased all types of emissions compared to automotive Diesel fuel. The only positive result was a slight decrease of the volumetric fuel consumption in some loads.

Keywords: Adulteration; Automotive Diesel; Heating Diesel; Emissions; Diesel engine

1. Introduction

The Diesel engine has a good reputation for fuel efficiency, reliability and durability. These three characteristics, together with its improved emissions performance, mean that the Diesel engine continues to be the main power plant for transport worldwide [1].

* Corresponding author. Tel.: +30-210-5127-207; fax: +30-210-6241-559.
E-mail address: sskallig@mail.ntua.gr (S. Kalligeros).

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Air pollution caused by Diesel emissions, especially NO_x, particulate matter, carbon monoxide and unburned hydrocarbons, has been a noteworthy matter [2]. In Europe and the United States, legislative efforts towards improving air quality not only lead manufacturers to develop and introduce further improved emission control systems [3], but also they trigger demanding requirements on the oil industry towards producing advanced fuels. Therefore, much work on the effects of fuel properties on the emissions and engine performance has been performed worldwide [2,4–6].

Fuel marketers try to supply Diesel fuels with high detergency, thermal stability, high cetane index, low temperature operability and high energy content, and additionally, they try to contribute to reduced engine emissions. As a result, the role of fuel quality has drastically changed over the years, from a constant parameter to a design variable, especially in Europe where the market of Diesel powered vehicles has increased rapidly [7]. In this sector, Diesel engines are designed to pass a set of emissions certification limits, where the fuel is a major design parameter.

The fuels produced by the refineries usually comply with the legislation, but alterations in the fuel properties may occur during their transportation and up to the point where the fuel is dispensed into the consumer car tanks for a number of reasons. Mainly, three types of Diesel fuel are sold in Greece as part of the European Union Directives: automotive Diesel fuel, domestic heating Diesel fuel and marine Diesel fuel [8–12]. Domestic heating Diesel is cheaper than automotive Diesel. It is coloured red and contains furfural as a chemical marker at a proportion of 20 mg/l. It also has sulfur contents up to 2000 ppm (0.02 wt%).

The large price difference of domestic heating Diesel with automotive Diesel, due to the different tax policy, is the main motive for the adulteration. The most common practice in the illegal market is to remove the colour from the heating Diesel with a clay treatment using discolouring earths and then sell them as automotive Diesel. During the discolouring process, the marker may also be removed [13].

In this paper, exhaust emission and fuel consumption measurements from a single cylinder, stationary Diesel engine are described. The engine was fuelled with automotive fuel blends adulterated with domestic heating Diesel in concentrations up to 100%. The results showed that the adulteration of automotive Diesel fuel with heating Diesel leads to increased emissions; the four adulterated mixtures tested performed in a similar way; they increased exhaust emission of particulate matter, resulted in increased nitrogen oxide and hydrocarbon emissions; and a slight decrease of the volumetric fuel consumption, especially in loads up to 1.25 hp.

2. Experimental procedure

For this study, a stationary, Diesel powered Petter engine, model AV1-LAB, was employed. The engine characteristics are cited in Table 1. The engine was fuelled with pure traditional road Diesel and adulterated mixtures containing 25%, 50%, 75% and 100% heating Diesel. The emission tests included HC, NO, NO_x and particulate matter emission measurements under various loads up to 5 hp, the load being measured by shaft output. The volumetric fuel consumption was checked as well. Two exhaust emission analyzers were used: a Horiba instrument (type MEXA 574-GE that gauges HC, and CO exhaust emissions) and a NO–NO_x analyzer (42C NO–NO_2–NO_x Analyzer High Level, Thermo Environmental Instruments Inc.). The specifica-