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EFFECT OF ENGINE OIL ON EXHAUST EMISSIONS

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Amount of regulated emissions (CO, NO_x, HC), and emissions of some groups of organic substances (volatile hydrocarbons, polyaromatics, and aldehydes) were measured in the standard ECE 83 test on spark ignition engine of a passenger car. The influence of the engine oil composition (mineral or fully synthetic) was examined. For both engine oils, exhaust emissions were measured with fresh oil as well as used oil at the end of the oil drain interval. Unleaded petrol and CNG were used as fuels in all experiments performed.

The main conclusion made from the tests is that polyaromatics is the only part of the exhaust emissions that was influenced with the nature of the engine oil. Effect on the other components of emissions (aldehydes and VOC) was negligible. Emissions of polyaromatics were almost twice higher for fresh mineral as for fresh fully synthetic oil. The amount of polyaromatics in the exhaust emissions increased slightly with mileage for fully synthetic and substantially more for mineral engine oil.

Keywords: engine oil, emissions, organic pollutants

1. INTRODUCTION

Amount and composition of pollutants emitted from automobile engines are influenced by many factors. The most important one is a technical condition of the engine and catalytic converter. Also composition and quality of fuel used play significant role. It is evident, that engine lube oil can participate in formation of some substances, especially high-boiling hydrocarbons, during their combustion in an engine cylinder. Although the amount of exhaust pollutants originated from lube oil is probably relatively low because of low oil consumption in new engines, these pollutants can be significant due to their high toxicity.

There are two ways to affect engine emission by engine oil quality:

-Lowering the content of precursors of toxic pollutants in lube oil, especially aromatics

-Lowering friction power losses using lube oil with lower viscosity or better lubricity

The work presented was aimed to the determination of emissions of different groups of pollutants from passenger car equipped with spark-ignition engine. Either mineral or fully synthetic engine oil was tested during mileage interval of 10 000 km. In order to separate the influence of used fuel, a car adapted for alternative use of compressed natural gas (CNG) was used for emission tests.

2. EXPERIMENTAL

For emission measurements, passenger car SKODA Octavia combi 1.6 was used with spark-ignition engine having displacement 1595 ccm and max. power 74 kW at 5600 rpm. The engine was adapted for alternative use of compressed natural gas (CNG). A standard three-way catalytic converter was mounted in the car.

All measurements were performed according to the standard exhaust emission test procedure ECE 83 in the engine testing laboratory DEKRA (Czech Republic). The emission test consists of two phases, first of which simulates cold start and low speed urban driving with frequent gear changes, while the second one simulates extra-urban driving at high speed.

The basic exhaust emissions were measured in a standard way using commercial analysers – HFID for HC, NDIR for CO and CO_2 and chemiluminescence analyser for NO_x.

A computer controlled home-made apparatus was used to trap organic pollutants from undiluted hot exhaust gases. The apparatus allowed sampling several types of organic compounds and comprised sections for:

- Trapping of C_1 to C_4 hydrocarbons into inert TEDLAR bags;
- Sorption of C_5 to C_{24} hydrocarbons onto tube filled with the polymeric adsorbent CARBOXEN 591 (Supelco);
- Sorption of C_1 to C_8 aldehydes onto a sorption tube filled with silica gel impregnated with 2,4-dinitrophenyl-hydrazine (DNPH);
- Trapping of PAH's and high-boiling organic compounds ($>C_{24}$) after freezing of exhausts to a temperature below -10°C (condensation of high-boiling organic compounds) and the sampling of cool exhaust through microporous glass fibre filter.

The identification and quantification of organic compounds were performed by solvent extraction (sample pre-separation) and final chromatographic analysis - capillary gas chromatography with mass (GC-MS) or flame-ionisation (GC-FID) detection, high-resolution liquid chromatography (RP-HPLC) with UV diode-array and spectrofluorometric detection.

Characteristics of compared engine oils, used in test vehicle, are presented in Table 1.

Table 1 Engine oils used in test vehicle for emission test

Engine oil	Fuchs Titan	Esso Ultron
SAE	15W-40	5W-40
Content of PAH in new/used oil (ppm)	30 / 1360	0 / 671

3. RESULTS AND DISCUSSION

In the Fig. 1, regulated emissions measured during ECE 83 test are presented. With respect to experimental error of emission measurement, there was no effect of engine oil

properties and composition. Small changes in condition of the engine, experimental condition, and other factors override the influence of lube oil. The use of CNG as fuel caused increase of total hydrocarbon emissions. However, hydrocarbon emissions from combustion of CNG comprise mainly methane, which is less toxic than higher, namely aromatic hydrocarbons. On the other hand, emissions of nitrogen oxides decreased average by about 30 %.

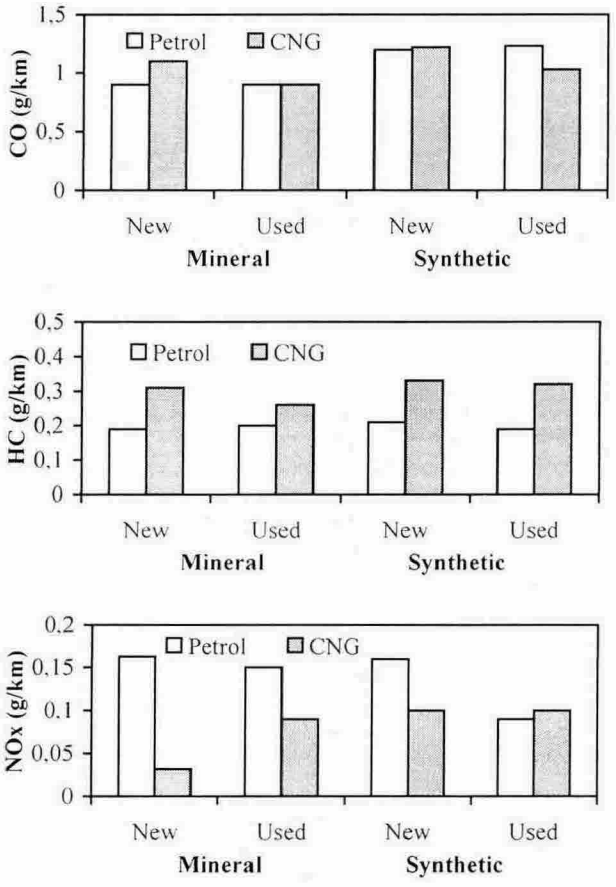

Fig. 1 Comparison of regulated emissions of tested car with mineral and synthetic oil

In Fig. 2, there are results of determination of different groups of organic pollutants found in exhaust, as obtained by instrumental analysis. Significant changes caused by engine oil used were observed at PAH emissions. With the use of mineral lube oil, total PAH emissions grow significantly. Further increase of PAH emissions takes place due to lube oil wear during increased mileage. As to volatile hydrocarbons and aldehydes, no change caused by lube oil composition was observed. The fuel type markedly affects emissions of volatile hydrocarbons; it is evident that with CNG-powered test, the amount of non-methane hydrocarbons is very low; these NMHC probably originated from cold-start of the engine at the beginning of ECE 83 test. During the cold start, the engine is powered with petrol for short period before its operation is stabilized. Also emissions of aldehydes decreased substantially with the use of CNG as the fuel.

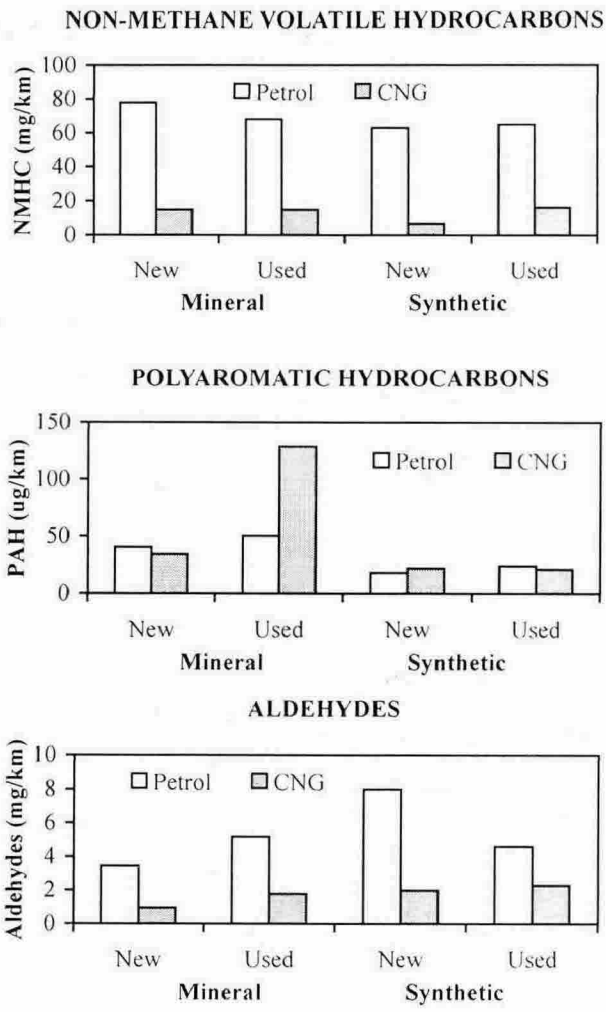

Fig. 2 Comparison of emissions of different groups of organic pollutants

4. CONCLUSIONS

Properties and composition of engine lube oil can affect engine operation in many ways. By the use of proper lube oil, fuel consumption, as well as friction wear of the engine can be reduced. However, emission characteristics are influenced in smaller extent. The most important changes were found in emissions of polyaromatics hydrocarbons, which can be formed from high boiling hydrocarbons present in lube oil. The use of fully synthetic lube oil can, therefore, contribute to the reduction of emissions of these harmful substances.

Acknowledgment

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