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ENVIRONMENTAL POLLUTION BY MOTOR-CARS EQUIPPED WITH COMPRESSION-DIESEL ENGINES

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Summary. The paper presents unfavourable phenomena occurring during the operation of compression Diesel engines. Exhaust gas smokiness degree was used as a comparative indicator. The changes taking place during engine operation were discussed according to the type of used fuel and engine operation parameters.

Key words: engine, indirect injection, fuel type

INTRODUCTION

In recent years, a dynamic development has taken place in means of road transport accompanied by a considerable increase in the number of motor-cars equipped with compression Diesel engines on our roads.

It is important to examine how it affects the natural environment and whether some technical, organisational and legal actions could be taken to counteract harmful consequences. The use of compression Diesel engines is caused by implementation of three basic requirements:

- low fuel consumption (fuel-efficient operation),
- low exhaust gas toxicity, and
- high flexibility (good dynamic properties).

To solve the problem of fuel-efficiency improvement and toxicity reduction in case of engines in heavy load trucks, a new approach was necessary departing from traditional solutions. Continuous tightening of standards and regulations protecting the natural environment as well as necessity of the reduction of costs connected with fuel consumption forced manufacturers to achieve a substantial progress. As the final result, we obtained technical solutions which, owing to lower fuel consumption, have reduced the global amount of toxic components ejected by engines to the atmosphere . Thus, the key problem allowing the fulfilment of the first two requirements is to reduce engine fuel consumption. The third requirement must be consistent with the two previous ones but at the same time has to provide the car driver with the full use of vehicle traction capabilities.

The design of combustion engines is subject to continuous enhancement in order to improve their operating parameters. These parameters characterise engine operational indicators, such as torque or power output. With respect to compression Diesel engines, an important indicator is also exhaust gas smokiness. When analysing these popular indicators, one can state that mean effective pressure being directly dependent on engine filling ratio has a significant effect on their values. This quantity determines what charge mass has really got into the cylinder during the charging stroke. At the same time, it is possible to increase its value, for example by engine supercharging. This can be done by using appropriate devices but this may necessitate taking away a certain amount of energy which is needed to propel these devices . Dynamic supercharging, consisting in the use of wave phenomena in inlet conduits, can also be used for better cylinder filling. One should remember at the same time that larger cylinder filling with air allows better combustion of injected fuel dose and at the same time it decreases the toxic effect of exhaust gases by reduction of their smokiness level.

EXHAUST GAS SMOKINESS OF INDIRECT-INJECTION ENGINES

Since the filling conditions for indirect-injection engines are worse than those for direct-injection ones, it was interesting to examine experimentally their exhaust gas smokiness level and attempt to reduce this indicator by using plant-origin fuels (RME).

The engines being characterised with respect to their design by indirect injection to the vacuum chamber of the Ricardo Comet Mark V type [2, 3] (Fig. 1) were used for the tests.

They are four-cylinder high-speed engines designed for propelling motor-cars (Volkswagen cars) in the un supercharged version JK and the turbocharged version CY, the technical data of which are presented in Table 1.

Tab. 1. Technical characteristics of the tested engines [4]

	JK-type engine	CY-type engine
Engine cycle type	four stroke with self-ignition	
Cylinder number	4	
Cylinder block configuration	in-line, single-row, vertical	
Injection system	indirect	
Combustion chamber type	turbulent , Ricardo Comet Mark V type	
Cylinder bore	76.5 mm	
Piston stroke	86.4 mm	
Swept volume V_{ss}	1.588 dm3	
Compression ratio ε	23	
Power rating	40 kW	51 kW
Rated rotational speed	4800 min^{-1}	
Maximum torque	104 Nm	133 Nm
Maximum torque rotation speed	2000 min^{-1}	2600 min^{-1}

Until recently, engines with that type of combustion chamber were commonly used to propel VW, Citroen, Renault, Peugeot, FIAT, Toyota, Mazda and BMW cars [2, 3, 4], a large number of which moves on national roads and therefore it was purposeful to present their environmental effect in the form of exhaust gas smokiness.

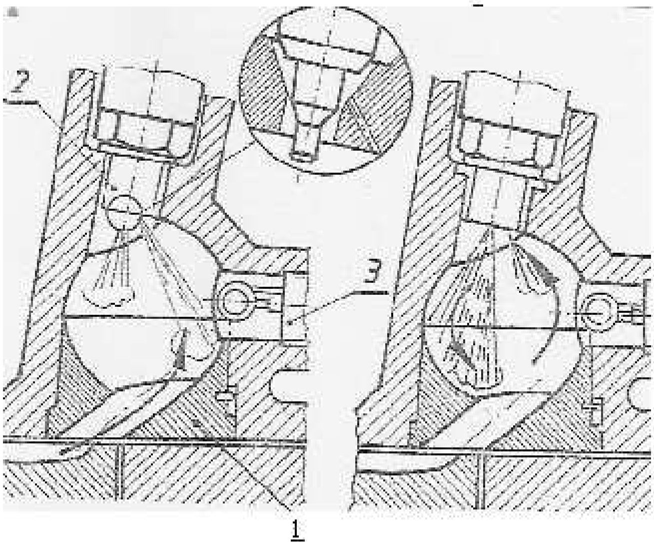

Fig. 1. Turbulent combustion chamber of the Comet Mark V type
1. glow insert, 2. spray nozzle, 3. glow plug

Test results for JK engine are presented in Figure 2.

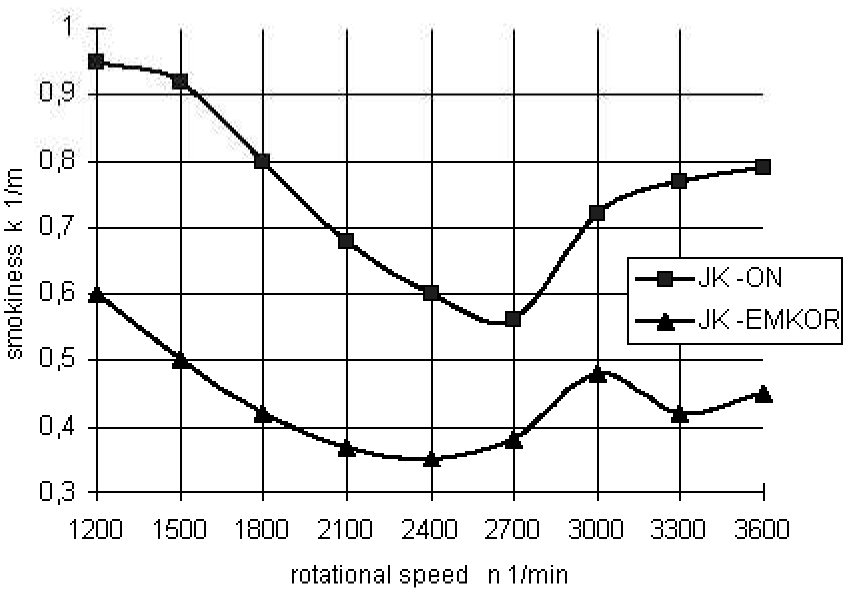

Fig. 2. Cumulative external characteristics for the smokiness coefficient of JK engine fuelled with Diesel fuel ON and biofuel EMKOR

The minimum values of smokiness coefficient occur at different values of the rotation speed of engines under testing, i.e.:

a) at rotation speed 2400 min^{-1} in case of the operation of unsupercharged engine of the JK type fuelled with rapeseed methyl esters,

b) at rotation speed 2700 min^{-1} in case of the operation of engine fuelled with Diesel fuel.

The maximum values of this operation parameter occur at identical rotational speed of engines under testing (1200min^{-1}), which corresponds with their maximum load. The range of smokiness coefficient differs for the tested engines.

Difference in the smokiness coefficient for both types of fuel ranges from 0.2 1/m at rotational speed 2700 min^{-1} to 0.35 1/m at rotational speed 1200 min^{-1}. Thus, a favourable effect of RME on environmental contamination by the engine is clearly visible, preserving the constant value of its other operation parameters.

Identical examinations were carried out on the turbocharged engine, obtaining the values presented in Figure 3.

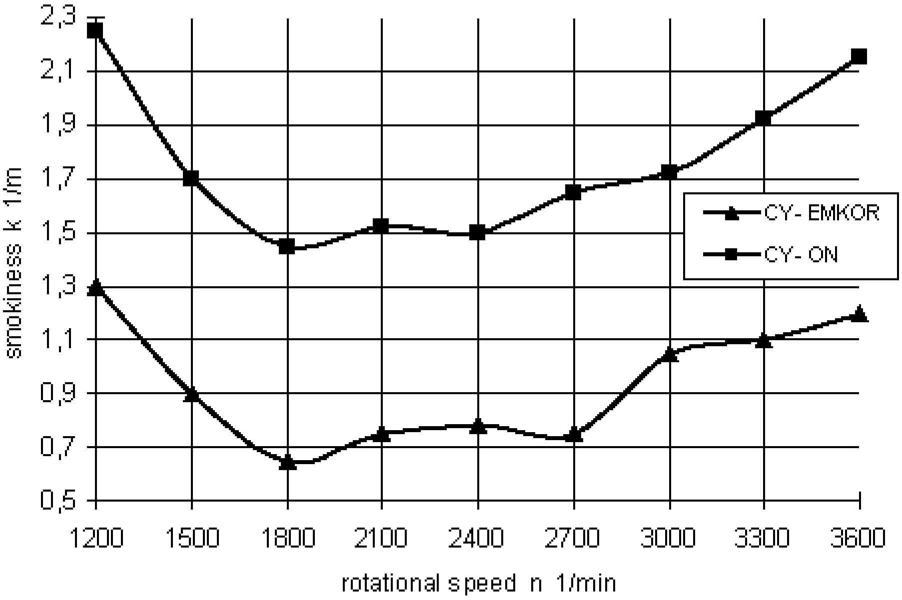

Fig. 3. Cumulative external characteristics for the smokiness coefficient of CY engine fed [fuelled] with Diesel fuel ON and biofuel EMKOR

For the supercharged engine, the smokiness curve is also favourable in case of feeding it with bio-fuel RME. Differences between exhaust gas smokiness level of the tested engine amount to 0.4 l/m within the whole range of useful rotational speeds. The lowest value of smokiness level occurs at the rotational speed 1800 min^{-1} for both types of fuel, i.e. near the maximum torque of a supercharged engine (2000 min^{-1}), but low smokiness level remains up to rotational speed 2400 min^{-1}, which corresponds to the maximum torque of supercharged engine. Larger absolute values of exhaust gas smokiness level for supercharged engine maybe explained by worse conditions of the formation of air-RME mixture because no adjustments were carried out which are required when supercharging the engine for obtaining larger engine efficiency [1].

Exhaust gas smokiness level of the tested engines fuelled with bio-fuel RME is lower for the whole range of rotational speeds when compared to the feeding with Diesel fuel. Differences in the value of smokiness coefficient for the engine fueled with respective fuel types come up even to 50% in favour of the feeding with bio-fuel RME .

The presented results of exhaust gas smokiness examinations for indirect-injection engines are useful for carrying out further analyses aiming at examination of the effect of engine operational factors on airborne contamination in the environment.

CONCLUSIONS

When analysing the study results, a visible reduction of the smokiness level in compression-ignition engines fuelled with bio-fuel can be observed.

At the same time, modern designs of heavy load truck engines equipped with direct injection ensure better and more environment-friendly course of air-fuel mixture combustion. This confirms the trend of abandoning the use of indirect-injection engines for propelling motor-cars due to larger fuel consumption and exhaust gas smokiness. It is consistent with the assumptions mentioned in the paper's introduction.

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SZKODLIWY WPŁYW POJAZDÓW Z SILNIKAMI DIESLA NA ATMOSFERĘ

Streszczenie. Artykuł przedstawia niekorzystne zjawiska występujące podczas pracy silników z zapłonem samoczynnym. Jako wskaźnik porównawczy posłużył stopień zadymienia spalin. Omówiono zmiany zachodzące w pracy silnika w zależności od rodzaju zastosowanego paliwa i parametrów roboczych.

Słowa kluczowe: silnik, wtrysk komorowy, rodzaj paliwa