THE METHODS OF ASSESSMENT OF CAR TECHNICAL CONDITION REGARDING ENVIRONMENTAL PROTECTION

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Abstract

This paper considers the results of studies on examination methods in scope of environmental protection such as exhaust emission, fuel consumption and noise emission. The reduction of exhaust gas emission of modern compression and spark ignition engines requires an optimization of existing diagnosing methods as well as the investigation of new approaches. The results of car inspections regarding environmental protection for more than four thousand vehicles have been compared to the requirements of ECE regulations and those of particular car producers. Eight hundred cars with a fault of gas emission and fuel consumption were examined in order to define typical damages. The possibilities of diagnosing the damages of mechanical and electrical systems of the engine have been carried out using electrical value measurements and exhaust gases analysis. The test results show that there is a necessity of elaborating new diagnosing methods enabling to find damages regarding exhaust emission and fuel consumption at their initial stage. One of the possible methods which could be applied is the evaluation of the quality of combustion process considering the values of parameters of engine performance coming from the detectors mounted to the engine. The so far carried out examinations have revealed that some mechanical damages of engines such as operating wear or unexpected faults do not make the diagnosing system react to the information.

Keywords: *car technical condition, traffic emission, environmental protection, vehicle inspection*

1. Introduction

The international legislation determines technical requirements, the need for periodic technical inspection, requirements for service and the way of testing particular systems of a car.

All cars which take part in road traffic must be periodically examined in the majority of European countries. The range of inspections and their frequency are determined according to the law in each country. The methodology and frequency is determined by domestic legislation. The agreements of Economic Commission for Europe establish rules for periodical technical inspection of wheeled vehicles. In each country the rules should cover the categories of wheeled vehicles concerned and the frequency of their inspection, the equipment and parts to be inspected, test methods by which any performance requirements are to be demonstrated and conditions for granting inspection certificate and their reciprocal recognition. The range of periodical inspection and detailed methodology are determined separately in each country.

The increasing amount of car transportation units and shortcomings in energy resources as well as environmental pollution threatening require the reduction of energy consumption and generation of pollutants in transport.

The reduction of exhaust gas emissions of modern compression and spark ignition engines require an optimization of the existing diagnosing methods as well as the investigation of new approaches.

Stringent emission regulations have led automotive manufacturers to develop systems which can detect and diagnose any fault which may cause tailpipe emission to rise above a permissible threshold. This can be achieved by continuous monitoring the automotive data characteristics for any abnormal behaviour. The need to minimize engine failures has directed the research towards the study of new monitoring and diagnostic techniques based on non-intrusive methods.

2. The purpose and methods of investigation

The results of vehicle examination which have been presented in this paper were obtained from investigation of the influence vehicle technical conditions on traffic emission and traffic safety [1].

The vehicles among other things were examined in order to define technical condition and typical faults in the scope of environmental protection. The analyses concentrated on the possibilities of diagnosing any faults which can be determined using conventional diagnosing methods, classified for the kind of fault (indicating the exact system). The way of eliminating the fault was also defined. The methodology of examination was elaborated for the following category of vehicles, passenger cars (M_1) and light duty vehicles having a maximum mass not exceeding 3.5 tonnes (N_1), buses having a maximum mass exceeding 5 tonnes (M_3) and duty vehicles having a maximum mass exceeding 3.5 tonnes (N_2 and N_3). Specification of the examined vehicle age in each category has been presented in Tab. 1.

Tab. 1. Specification of the examined vehicle age

Vehicle category	Percentage of vehicles in age group					Total number of vehicles
	2-3 year	4-5 years	6-7 years	8-9 years	10 years and more	
$M_1 + N_1$	8%	9%	30%	41%	12%	4200
$M_3 + N_2 + N_3$	20%	20%	10%	15%	35%	380

For each category of vehicles examination and tests according to binding rules of periodic vehicle inspections were carried out. The investigations of the cause of faults were carried out for vehicles which did not meet the legislative or producers requirements in the scope of environmental protection and fuel consumption. During the examinations different diagnostic methods such as diagnosing through OBD systems, the measurements of electrical values while testing, organoleptic methods, road and stand tests were applied. Eight hundred cars with a fault of gas emission and fuel consumption were examined in order to define typical damages.

Additionally, two hundred models of cars of twenty eight different makes have been tested regarding the possibilities of applying testers of on-board diagnosing systems and diagnosing damages. Possibilities of communicating the testing equipment through diagnosing connected with OBD systems have been examined as well as monitoring of the already existing system tests in a car. Uniformity of communication protocol with OBD standards have also been tested [2].

3. Methods of technical inspection in the scope on emission of toxic compounds and higher level of noise

The requirements for vehicles concerning a level of the pollutant emission have been determined by ECE Regulation No. 83 according to Revision 3, Regulation No. 24, Regulation No. 96 and Regulation No. 101. These regulations concern the exhaust emission at normal and low temperature, the emission of visible exhaust pollutants, evaporative emissions, emissions of crankcase gases, the durability of pollution control exhaust devices and on-board diagnostic (OBD) systems of motor vehicles, the measurement of the emission and fuel consumption.

The minimum inspection requirements in the scope of environmental protection have been determined by ECE Agreement Rule No. 1 concerning the adoption of uniform conditions for periodical technical inspection of a wheeled vehicle and the reciprocal recognition of such inspections. According to this Agreement, the check of exhaust emission of vehicles with positive – ignition engines (spark ignition engines) includes visual inspection of the exhaust system, visual inspection of any emission control equipment fitted by the manufacturer in order to check that it is complete and in a satisfactory condition, measurement of the carbon monoxide (CO) content of the exhaust gases when the engine is idling. However, in cases when the exhaust emissions are controlled by the advanced emission control system such as a three-way catalytic converter that is lambda-probe controlled, determination of the efficiency of the vehicle's emission control system is realized additionally by measuring the lambda value.

The inspection of vehicles with compression ignition engines includes visual inspection of any emission control equipment fitted by the manufacturer in order to check that it is complete and in satisfactory conditions. Exhaust gas opacity to be measured during free acceleration (no load from idle up to cut-off speed) with gear lever in neutral and clutch engaged.

The methodology which has been applied during the periodical inspection is mainly in accordance with ECE requirements. During the inspection for spark ignition engines the contents of carbon monoxide and hydrocarbons in exhaust gases are measured. The lambda value is calculated using the simplified Brettschneider equation. For compression, engines exhaust gas opacity is only measured. The limit values are determined according to the law regulations. The law limit values are not very restrictive as those of the requirements of vehicle producers. In many cases vehicle which was examined during the periodical inspection and which technical conditions met law requirements however it is faulty according to producer recommendations [3, 4]. The contents of nitric oxides in exhaust gases have not been measured.

The level of noise requirements for vehicle has been determined by ECE Regulation. No. 51. The measurement of level of noise during the periodical inspection is carried out only in justified cases.

4. Results and discussions

About forty two per cent out of the total number of vehicles which were examined were faulty. The faults concerned damages in the scope of traffic emission, traffic safety, load safety, comfort of dive and travel. Seventy per cent of vehicles did not meet the requirements in the scope of fuel consumption and exhaust emission.

Examination results have been presented in Fig. 1. The analysis of faults for each category of the examined vehicles can be classified in the following groups: faults which cause higher emission of toxic compounds and higher level of noise, faults which have a direct impact on driving safety (brake system, steering system, suspension system), indicators and lights, non-emission faults of power transmission system, faults of elements and chassis systems which deteriorate the comfort of driving.

For passenger cars (M_1) 16 per cent of faults were connected with engine damages. It was 17 per cent for buses M_3 category and 12 per cent for vehicles N category.

The study which was carried out by others [5-7] established that the most common component failure is that of the engine (41%) and that the most common cause of failure is the over-running (21%). The total contribution to the cause of failure of manufacturing or design errors, raw material defects and storage procedures is 33%. The high proportion of failures due to improper repairs (18%) represents an area where increased training in the reconditioning and regular periodical inspections may yield significant dividends.

To compare the results of examinations of passenger cars in this case, to the results of investigations of cars which were not older than 3 years, where twenty six per cent out of the total number of faults were engine damages [2], the percentage of engine fault has been decreased significantly. It has been caused by the increase of normal wear during operation, dynamic and corrosion fatigue in other systems.

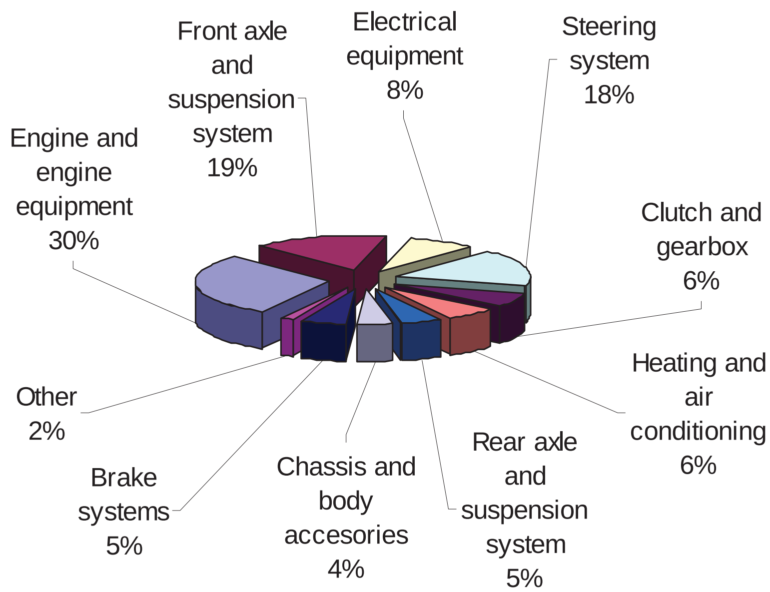

Fig. 1. Structure of vehicle faults [1]

The types of engine faults have been presented in Fig. 2. Twenty eight per cent of engine faults were connected with fuel consumption but the results of the examinations in the scope of exhaust emission were satisfactory Fig. 3.

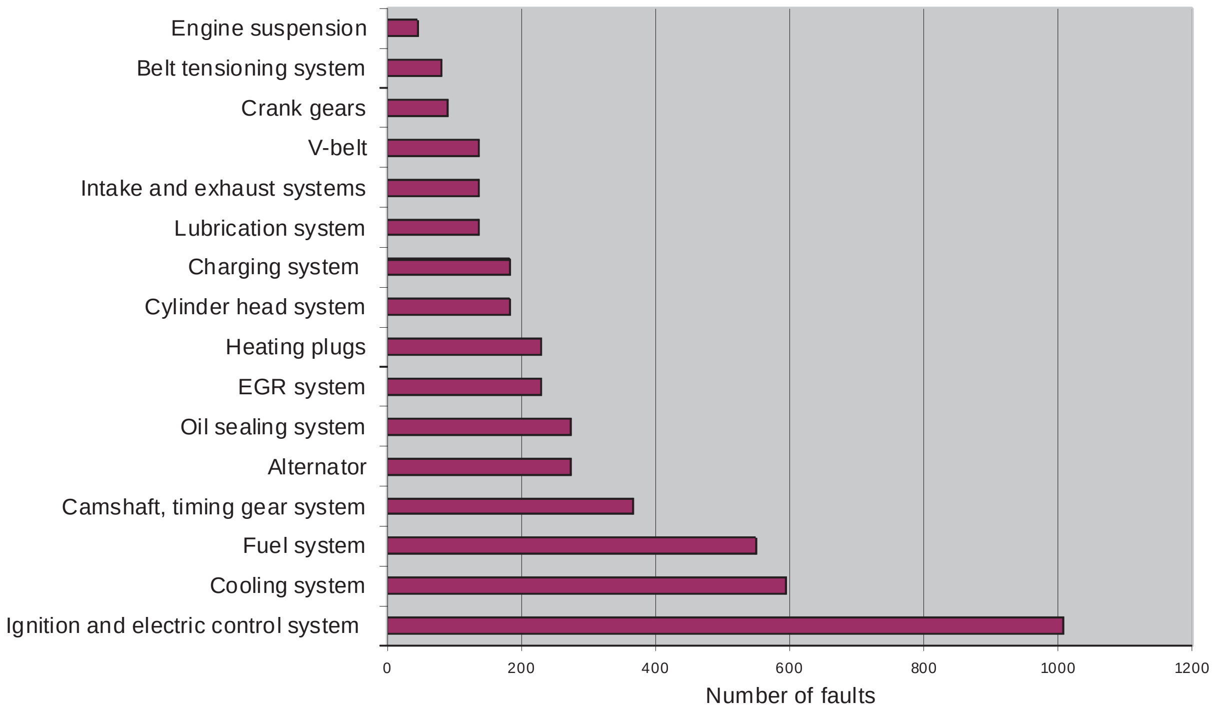

Fig. 2. Structure of engine faults

Taking into consideration the possibilities of fault diagnosing and the technology of repairs it is possible to distinguish the following aspects: mechanical faults, electrical control and ignition system. The examined cases concentrated on issues of complete breakdown of the engine, increased fuel consumption and pollutants, damages which deteriorate operating conditions of the engine, which in turn lead to more intensive wear of friction pair and also to damages of auxiliaries and mounting of the parts which do not have any impact on the major engine systems.

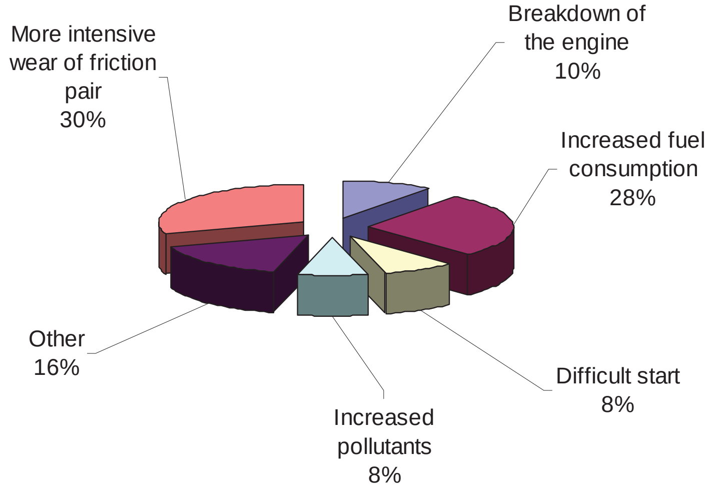

Fig. 3. Type of engine faults

Most of the damages (aprox. 40%) including those complete breakdown of the engine which were not indicated by control units and OBD system and also by OBD testers.

Apart from measurement of of toxic compounds in exhaust gases three methods of diagnosing have been used in order to locate the engine fault and to define the type of fault: using the OBD system, measurements of electrical values while testing the technical conditions of a car as well as organoleptic methods at checking and examining the engine (Fig. 4).

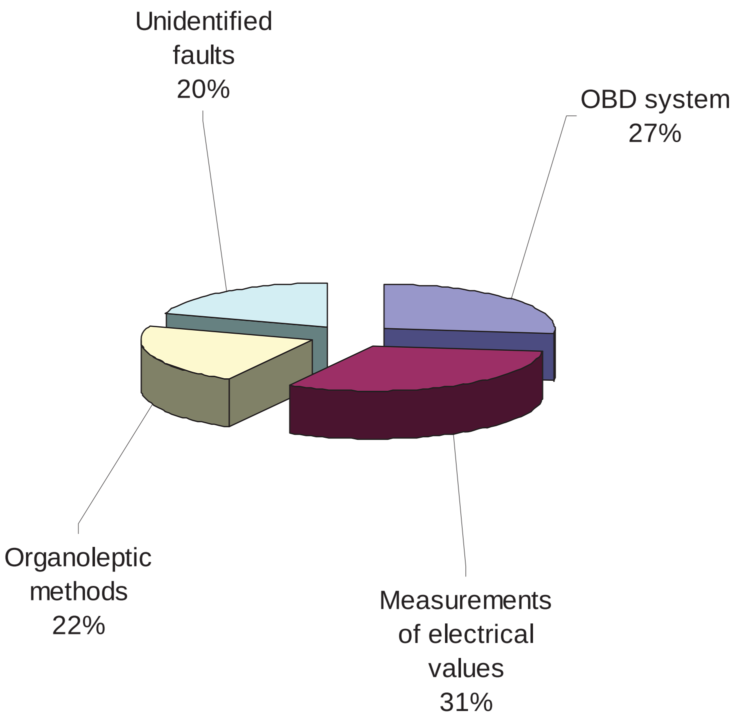

Fig. 4. Effectiveness of diagnostic methods

Although all possible diagnosing procedures were used in the technology of repairs, some faults have not been defined until particular systems where disassembled and the parts were verified or some elements of electrical system were replaced by previously checked parts.

Possibilities of communicating testing equipment through diagnosing connection with OBD systems have been examined as well as monitoring of the already existing system tests in a two hundred models of passenger cars. Uniformity of communication protocol with OBD standards have also been tested. Protocol of communication and data from emission monitors have been defined during the examinations for each vehicle.

Although on-board diagnostics systems are standardized, there have been some problems with using the testers for diagnosing the engine. The diagnosing systems have been operating in accordance with OBD I, EOBD, OBD II California norms, and CAN, ISO 14230, ISO 9141 standards.

In 12 out of 40 tested models of diesel engines it was not possible to use the testers. There was no communication between the tester and the system and there were also no standardized connectors. Another drawback was the lack of possibility to make the right connection work properly and emission monitors could not be defined. For only 7 SI engines the tests were not possible to be carried out. The type of the used tester influenced the possibilities of correct diagnostics.

Conclusion

The test results show that there is a necessity of elaborating new diagnosing methods enabling to find damages regarding exhaust emission and fuel consumption at their initial stage. One of the possible methods which could be applied is the evaluation of the quality of combustion process considering the values of parameters of engine performance coming from the detectors mounted to the engine. The so far carried out examinations have revealed that some mechanical damages of engines such as operating wear or unexpected faults do not make the diagnosing system react to the information. This can be a result of algorithms of adaptation of the engine control system which compensates the impact of faults.

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