THE APPLICATION OF ON-BOARD DIAGNOSTICS SYSTEMS FOR ASSESSING THE TECHNICAL STATE OF AUTOMOTIVE VEHICLES

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Abstract

This article presents the results of investigations regarding the use of on-board diagnostic systems to assess the technical state of automotive vehicles, and the possibilities of early fault detecting. The examinations were carried out in order to establish if it is possible to evaluate the level of compatibility between diagnostic test units and on-board diagnostic systems in over three hundred models of vehicles which were produced by different manufactures. The investigations concerning the influence of examination conditions, the type of faults and the vehicle age upon the results and reliability of diagnostic tests were carried out. The suitability of fault codes which were recorded in the memory of diagnostic system while the vehicle was operating have been determined as far as the recognition of the type of faults is concerned. Additionally, the examinations of engine on a test stand were carried out as well. Sensitivity of diagnostic systems was tested regarding the changes of work parameters of the engine. The faults of engine were deliberately provoked and were examined at the early stage by on-board diagnostic systems. The test results show that there is a necessity of elaborating new diagnosing methods enabling to find damages regarding safety in road traffic.

Keywords: *technical condition of a car, vehicle inspection, on-board diagnostic*

1. Introduction

All cars which take part in the road traffic must be periodically examined. The range of inspections and their frequency are determined according to the law regulation in each country. The methodology and frequency is determined by domestic legislation. The international legislation determines only common technical requirements for the particular systems of a car. The ECE regulations for vehicles determine technical requirements, provisions for the periodic technical inspection for these vehicles, requirements for service and a way of tests for systems which are important to traffic safety and environmental protection.

The agreements of Economic Commission for Europe establish rules for periodical technical inspection of wheeled vehicles. In each country the rules shall cover the categories of wheeled vehicles concerned and the frequency of its 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 basic methodology of examination of technical conditions which has been used during periodical inspections of vehicles was elaborated over forty years ago. It is necessary to elaborate new diagnosing methods enabling to find damages regarding traffic safety and environmental protection. One of the possible methods which could be applied is the evaluation of the technical condition of vehicle considering the values of parameters of performance of particular systems from OBD and detectors mounted as special equipment [1].

A new diagnostic systems for cars maintenance and repairs has been developed in recent years. These systems are employed for various types of diagnosing faults in cars and are available at

service level. Modern OBD systems are mainly based on simple limit system or plausibility check of some measured signals and on simple signal-based methods of car fault diagnostics and they have become increasingly important for two reasons [2-4]:

- legal requirements for OBD of all exhaust components and systems are more stringent,
- more complex control functions of electronically controlled systems of cars with a rising number of actuators and sensors.

The computer engine control results in smoother running of engine with the improved fuel performance and reduced emission of pollutants.

2. Methodology

The investigations were carried out in four stages. First, five hundred cars with faults were examined in order to define typical damages. The analyses concentrated on the possibilities to diagnose any faults which can be determined using conventional diagnosing methods, classified for kind of fault (indicating the exact system). The way of eliminating the fault was also defined. The examinations concentrated on all models of cars of the same make both with spark ignition and diesel engines. Specification of examined car age has been presented in Fig. 1.

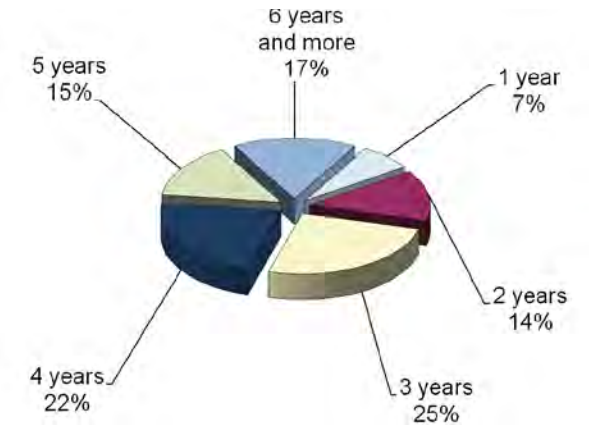

Fig. 1. Specification of examined car age

Next, five hundred cars of different producers were examined during periodical inspection. The vehicles were examined in order to define technical states and typical faults significant for assuring safety in road traffic and exhaust emission. The analysis was concentrated on the feasibility of detecting faults, which can be determined using conventional inspection methods and different diagnostic methods such as diagnosing through OBD systems, the measurements of electrical values while testing, organoleptic methods, etc. The way of fixing the fault was also defined.

Three hundred models of cars of twenty eight different makes have been tested regarding the possibilities of applying testers of on-board diagnosing systems for diagnosing the faults. The possibilities of communicating the testing equipment through the diagnosing connection with OBD systems have been examined as well as monitored by the already existing test systems in a car. Uniformity of communication protocol with OBD standards has also been tested. The protocol of communication and data from emission monitors have been defined during the examinations for each vehicle. Information cards have been prepared for each tested vehicle and they contained communication protocol data, emission monitors and the location of a connector which allows linking the tester to the OBD system.

Additionally, the examinations of engine on a test stand were carried out as well. Sensitivity of diagnostic systems was tested regarding the changes of work parameters of the engine. The engine faults were provoked deliberately and were examined at the early stage by on-board diagnostic systems.

3. Results of investigations of vehicle faults

The examination results for five hundred cars of the same make have been presented in Fig. 2. Structure of engine faults has been presented in Fig. 3.

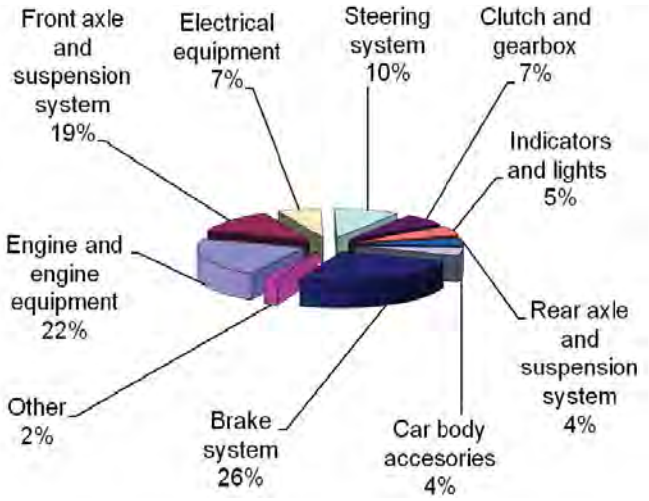

Fig. 2. Structure of faults in cars of the same make

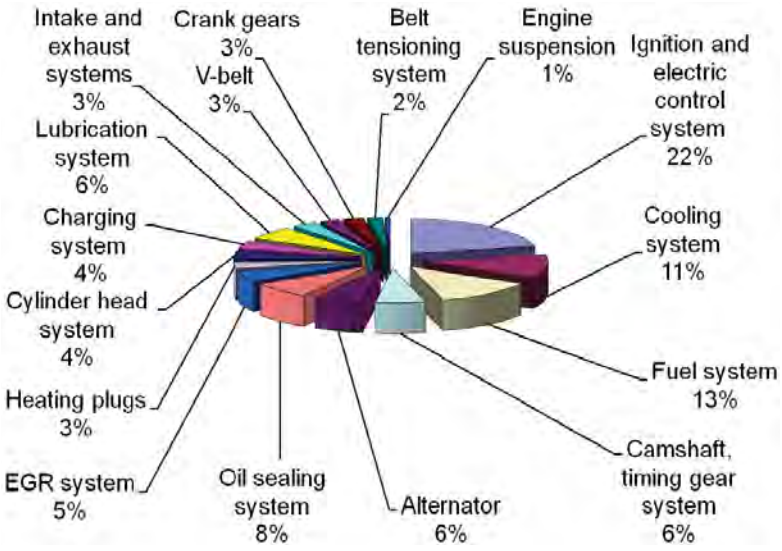

Fig. 3. Structure of engine faults

The analyzed faults can be classified in the following groups:

- faults which cause higher emission of toxic compounds and higher level of noise,
- faults which have 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.

The obtained structure of faults has been compared to similar results of examinations which were carried out during periodical inspections of different makes of cars. It can be stated that the percentage of most frequent faults has been the same for similar group of car age (Fig. 4).

The examined cases concentrated on issues of complete breakdown of the engine, increased fuel consumption and pollutants, damages which deteriorate operating conditions of cars and which in turn lead to more intensive wear of friction pairs and also to damages of auxiliaries and mounting of the parts which do not have any impact on the major car systems (Fig. 5).

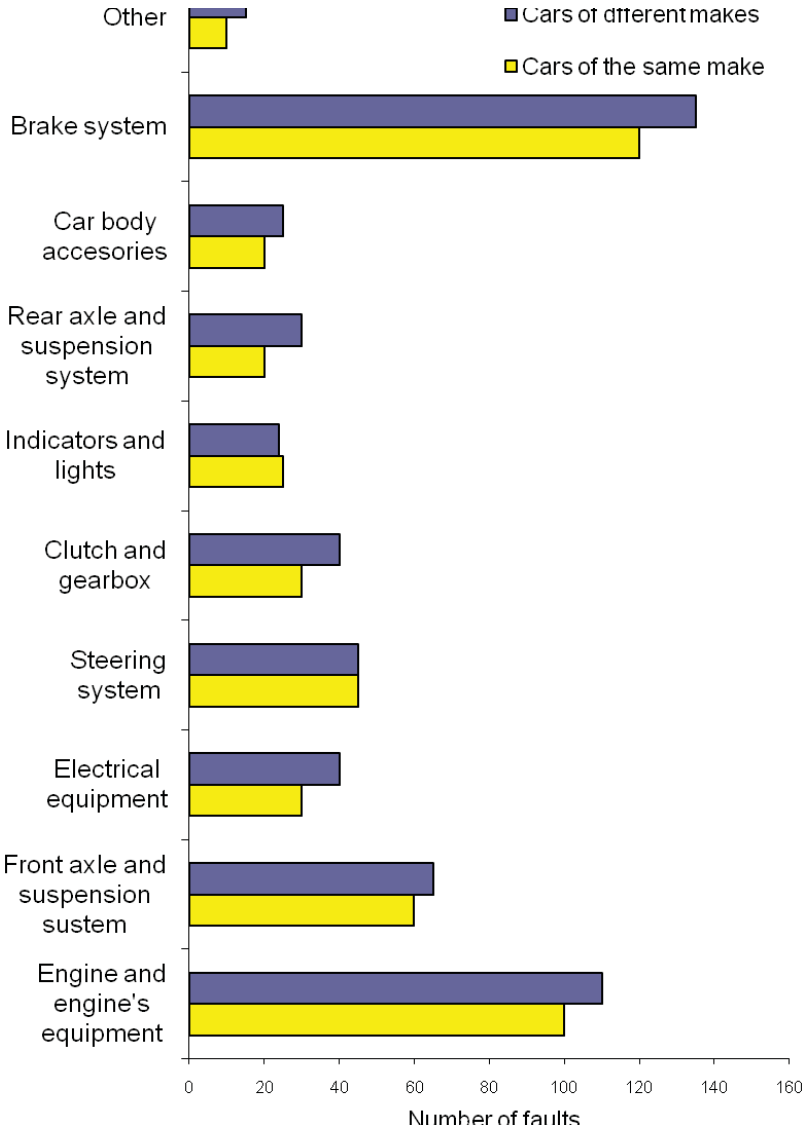

Fig. 4. Comparison of the results of examinations which were carried out for cars of the same make and different makes during the periodical inspections

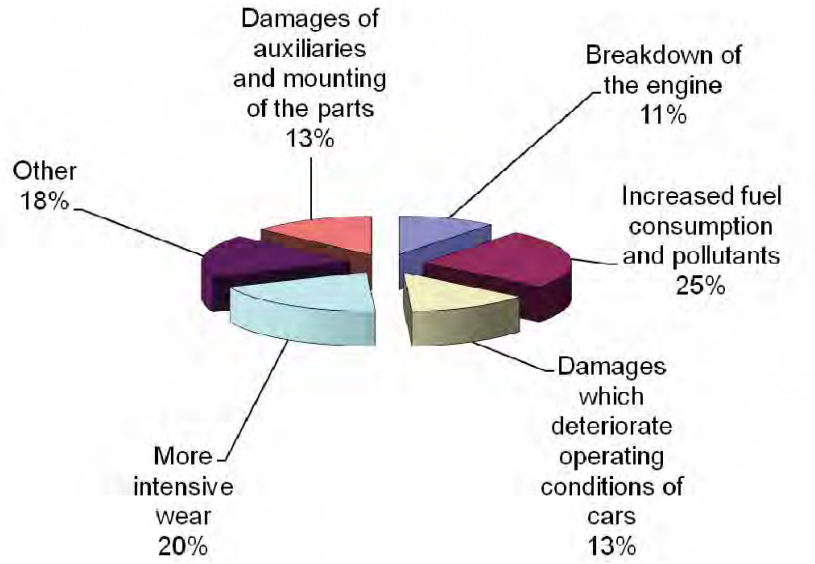

Fig. 5. Type of car faults

Four methods of diagnosing have been used in order to locate the car 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 car during road and stand tests. Although all possible diagnosing procedures were used in technology of repairs, some faults have not been defined until the particular systems where disassembled and the parts were verified or some elements of electrical system were replaced by previously checked parts (Fig. 6).

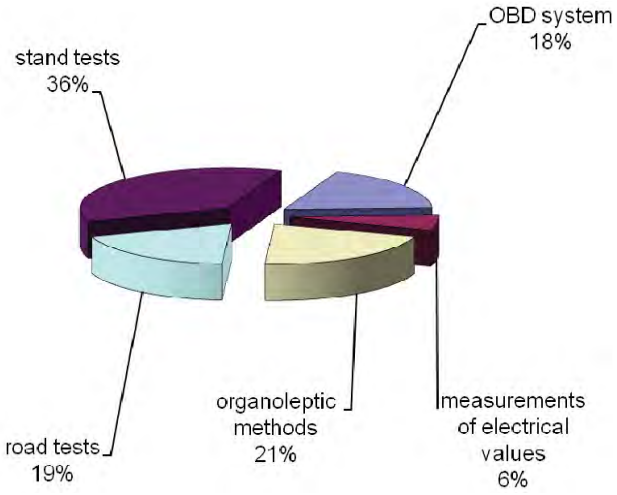

Fig. 6. The effectiveness of diagnostic methods

Taking into consideration the safety aspects, for 80 examined vehicles the initial test results showed that the technical conditions were poor. The additional diagnostic tests allowed to recognize both faulty systems and faulty elements of vehicles and the kinds of causes of damages. But in many cases faults were not recognized using common diagnostic methods. Taking into consideration the feasibility of fault diagnosis and the technology of repairs it is possible to distinguish the following aspects: normal wear during operation, abnormal mechanical faults, faults which are connected with engine control unit and electrical system, dynamic and corrosion fatigue.

Although on-board diagnostic 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 30 out of 68 tested models of cars with 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 8 models of cars with SI engines the tests were not possible to be carried out. The type of used tester had impact on the possibilities of correct diagnostic results. The results of tests were similar to the results of previous tests [5].

The results of tests concerning sensitivity of diagnostic systems regarding the changes of work parameters of the engine showed that only OBD tests detected faults at the early stage which had important influence on the exhaust emission. The OBD tests detected faults in many vehicles which were examined during the periodical inspection and which technical conditions met legal regulations requirements and the producer’s recommendations.

4. Conclusions

The results of investigations revealed that there is a possibility to improve the methodology of inspection of vehicles. A large number of faulty vehicles were the result of more restrictive criteria which were used in examination tests. The increased number of tests and the kinds of tests which

were applied during the examinations, allowed detecting far more types of faults compared to the results of common inspections.

The application of OBD test during periodical inspection regarding the level of the pollutants emission gives far better effects than the measurements by the emission control equipment. But in many cases, faults concerning the safety aspects were not recognized using the on-board diagnostic systems. The test results show that there is a necessity of elaborating new diagnosing methods enabling to find damages regarding safety in road traffic.

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