THE DEVELOPMENT OF THE INTERFACE SOLUTION FOR THE ACQUISITION OF INFORMATION FROM THE OBD SYSTEM OF THE VEHICLE

Karol Tucki, Remigiusz Mruk, Anna Bączyk, Katarzyna Botwińska
Warsaw University of Life Sciences, Poland

Received 21 05 2018; accepted 10 12 2018
DOI: 10.15544/njfcongress.2018.23

Abstract

The intensive development of the automotive industry has been observed over the past decades. The prices of cars have become more affordable for the average consumer, resulting in the increase in the number of the vehicles. This is connected with the increased exhaust emission which has an adverse impact on the environment. The proper standards whose role was to minimise the harmful effects of the vehicle on the environment were placed on the car manufactures. The on-board diagnosis systems have been developed for the permanent monitoring of the vehicles. The OBD system is one of them.

The aim of the study was to develop the interface with the use of simulation tools for the acquisition of information from the OBD system for the engine simulation of the vehicle in-service within the currently applicable WLTP test. The diagrams of the performed simulation of the operation of the vehicle within the WLTP test with the use of the Scilab Xcos environment and the results achieved from the applied interface were presented in the design part.

The mathematical relations were used to build a simulation model of the operation of the vehicle within the WLTP test which faithfully reproduces the real operating processes. The development of the simulation for the acquisition of the data on the current operating parameters of the engine allows for the creation of the programming solutions at the initial stages without the necessity for the operation of the programme with the real OBD system integrated in the vehicle.

Keywords: OBD, WLTP, diagnosis
JEL Codes: R40

Introduction

The intensive development of the automotive industry has been observed over the past decades. The prices of cars have become more affordable for the average consumer, resulting in the increase in the number of the vehicles (Lim et al., 2016; Calabrese, 2016). The car industry is considered one of the most intrusive in the natural environment (Mayyas, 2012). This is connected with the increased exhaust emission which has an adverse impact on the environment. Taking into account the health of citizens and deteriorating air quality, the states are forced to introduce the relevant provisions governing the emission of harmful substances (Skeete, 2017; Percival, 2017).

The proper standards whose role was to minimise the harmful effects of the vehicle on the environment were placed on the car manufactures. The on-board diagnosis systems have been developed for the permanent monitoring of the vehicles (North, 2005). These systems are responsible for the transfer of information between the particular controllers and actuators of the drive train and motor control system and they help significantly with the control process of the technical condition of the vehicle. At present, each newly produced vehicle must be equipped with such a system. It ensures the permanent monitoring of the emissivity of toxic compounds which affects the improvement of exhaust quality, contributes to the reduction of the environmental pollution and enhances the safety and general driving conditions of the user (Denton, 2017).

The on-board diagnosis (OBD) system is one of the diagnosis systems which monitor the engine performance and exhaust after-treatment systems. The OBD system was designed in a manner to ensure the assistance with the proper operation of the emission control appliances warning the user in case of failure so that the vehicle can meet the emission limits in its everyday use. The OBD standard is an important tool for the owners of the vehicles and the technicians because it provides important feedback information on the needs of the engine maintenance and informs of potential urgent repairs (Burelle, 2004; McCord, 2011). The OBD system helps with the repairs and services of the vehicles, ensuring a quick, economic and simple manner of the problem identification through the recovery of the important diagnostic data of the vehicles. The OBD is also an essential component of the maintenance and inspection programmes for the reduction of the exhaust emission during the use of the vehicle (Wierzbicki, 2003; Posada and Bandivadekar, 2015).

The most important quality criteria of on-board diagnosis system are credibility, scope and scope and meaning of the data sent by the system to the user. The meaning and form of information provided by the OBD system were standardised by ISO (International Organization for Standardization) and SAE (Society of Automotive Engineers) as binding international standards according to which an external diagnostic information reader must meet requirements of serial digital communication used in vehicles (Aliramezani et al., 2018; Frazel, 2016).

In future, it is planned to introduce the OBD III standard, ensuring the automatic notification of the services responsible for the technical supervision of the vehicle and the threat to the environment posed by the automotive industry. The OBD III standard is to be gradual, consisting in the development of already existing diagnostic systems of chassis and body assemblies as well as the systems responsible for the emission control of

Proceedings
ISBN 978-609-449-148-1 (on-line)

the toxic compounds. The automated transfer of the data on the vehicle condition forces the introduction of the relevant legal regulations for the consumer goods protection (Elmaghraby, 2014). The issue of the automated data transfer creates some anxiety in the society about the leakage of private data or their unlawful use. The OBD III standard therefore remains in form of a draft (Tomioka and Pires de Souza, 2016).

The aim of the study was to develop the interface with the use of simulation tools for the acquisition of information from the OBD system for the engine simulation of the vehicle in-service within the currently applicable WLTP test. The developed interface provides the user with the most important functionalities in the w diagnostic process of the vehicle.

Materials and methods

The performed simulation was developed on the Fiat Panda - 1.3 Multijet engine. The car has an inline 4-cylinder engine of a cylinder capacity of 1248 cm^3. The maximum power is 70 HP and the maximum torque of the drive train - 145 Nm. The fuel tank contains 35 litres. According to the manufacturer the fuel consumption with respect to the urban cycle amounts to 5.2 l/100 km and with respect to the extra-urban cycle - 3.6 l/100 km. The drive is transmitted to the front of the vehicle. The engine is connected with the manual gearbox which allows for the acceleration to 100 km/h within approx. 13 seconds. The engine ran on diesel.

Table 1. Basic technical data of Fiat 1.3 Multijet engine used in simulation

Parameter	Unit	Value
Arrangement of cylinders	–	inline
Number of cylinders	–	4
Type of injection	–	direct, multistage
Sequence of cylinder operation	–	1 – 3 – 4 – 2
Compression ratio	–	17.6
Diameter of cylinder	mm	69.6
Piston stroke	mm	82
Cylinder capacity	cm^3	1251
Maximum power of engine	kW	66
Engine speed for its maximum power nN	RPM	4000
Maximum torque of engine	N·m	200
Engine speed for its maximum torque nM	RPM	1750
Idling speed	RPM	850±20

The below figure presents the general diagram of the developed simulation of the engine operation which allows for the achievement of the parameters compliant with the standard of the OBD system as part of the implemented driving cycles compliant with the standards of the WLTP test (fig. 1). The simulation for the engine of the vehicle used in the study was carried out in the Scilab simulation environment. The special blocks for the calculation of the quested values were created by means of the Xcos tool and its components (Campbell et al., 2006). The individual blocks perform specific tasks:

- „Test" – The block generates signals of WLTP and NEDC driving tests in the form of: vehicle speed [km/h], force on wheels [N], calculated on the basis of the standardised data in the framework of the tests;
- „Drive train" – The block performs calculations on the basis of dynamic diameter of vehicle wheel in motion, final drive ratio and gear ratio, instantaneous mileages: vehicle speed [m/s], rotational speed [rad/s] of gearbox input shaft, torque on gearbox input shaft [N*m];
- „Limitations for engine" – The simulation block controls correctness of instantaneous values of rotational speeds and torque calculated during the simulation;
- „Combustion in engine" – The simulation module, using characteristics of hourly fuel consumption and hourly air demand, taking account of rotational speeds and torque, introduced to the simulation for the selected engine, calculates instantaneous values of fuel and air consumption;
- „OBD" – The module is responsible for preparing the data achieved during the vehicle simulation in the driving test in the form compliant with the OBD system standard. This module allows for reading dynamic parameters, changing over time and depending on results of engine simulation and static parameters the changes of which were not taken into account in the simulation.

Proceedings
ISBN 978-609-449-148-1 (on-line)

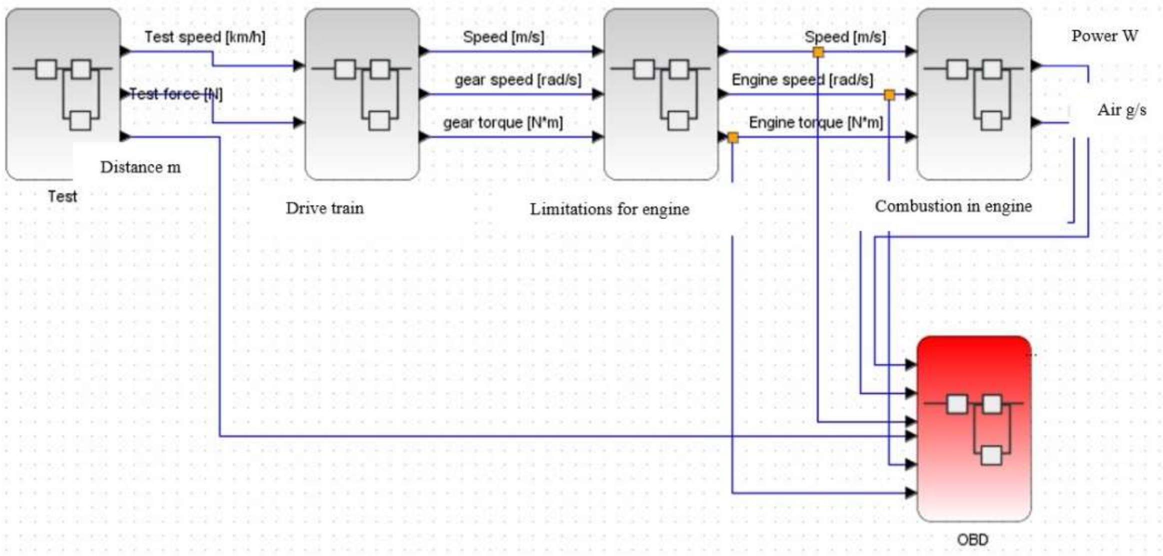

Figure 1. General diagram of developed simulation of vehicle operation as part of WLTP test with signal generation module of OBD standard

The WLTP test (World Harmonized Light Vehicle Test Procedure) was developed in order to carry out the effective emission measurements and to realise the emissivity results. During the research on its implementation, more factors, such as the average temperature at which the car operates (13°C) and the impact of accessories and configurations of engine and transmission versions, were taken into account (Tsokolis et al., 2016). This currently applicable test presents the car movement conditions in the most reliable manner.

Results

The below figure presents the simulation results of the operation of the "Test" simulation block for the WLTP test in the form of the transients of the values: speed of the vehicle v[km/h], distance travelled by the vehicle d[km], wheel contact force F[N] and the number of the selected gear in the gearbox p[-].

It is clear that the speed of the vehicle did not exceed 50 km/h during first 1500 seconds. Even after the increase of the speed to over 100 km/h, the wheel contact force did not change and its amplitudes become smaller. This means that the higher the speed the smaller wheel contact force of the moving vehicle.

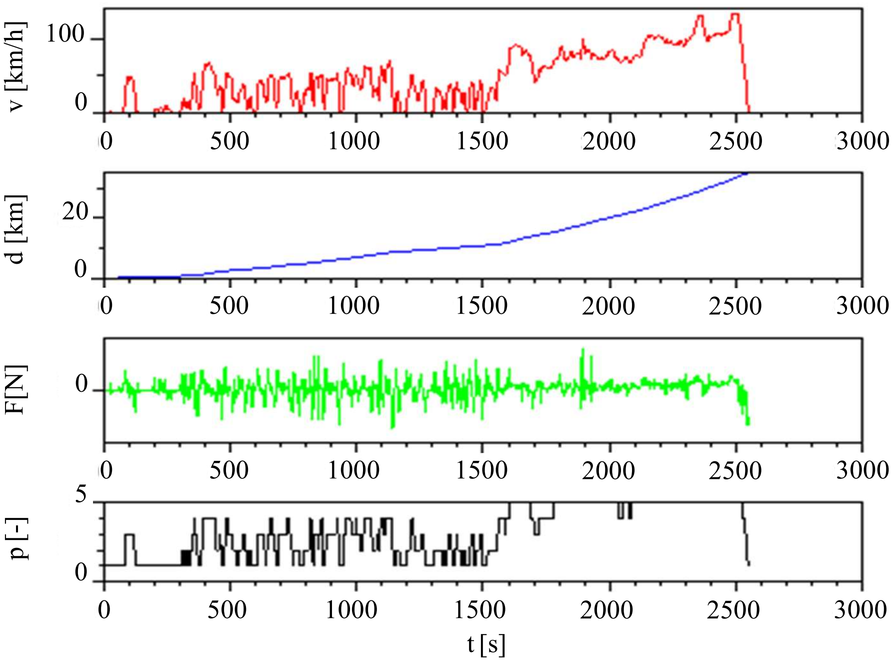

Figure 2. Operation results of "Test" simulation block responsible for signal generation of driving test (WLTP)

Proceedings
ISBN 978-609-449-148-1 (on-line)

The transients of the parameters obtained during the operation of the of "Combustion in engine" simulation block include: engine operation signal (value 1 - on, value 0 - off), mechanical power generated by engine Ne [kW], power delivered by fuel Nch [kW] and calculated temporary engine efficiency n [-]. The below figure shows the relation between the power generated by the engine and the power delivered by the fuel – the engine performance is based on the power achieved from the fuel combustion.

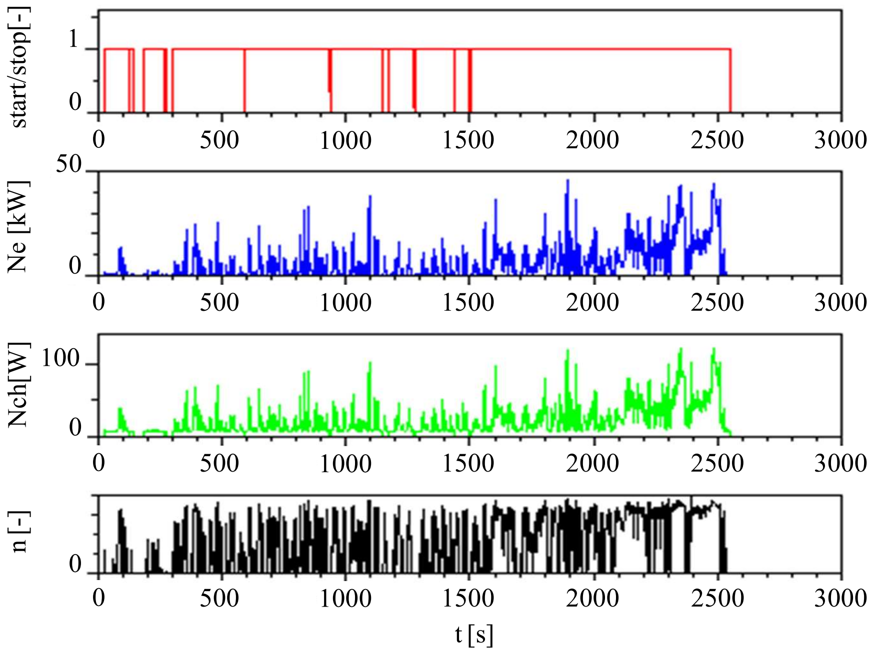

Figure 3. Operation results of "Combustion in engine" simulation block responsible for simulation of engine run on diesel (WLTP test)

The parameters obtained during the operation of the of "Combustion in engine" simulation block for the WLTP test converted for the compliance in relation to the quantities required in the OBD system are respectively: rate of power generated by engine [%], coolant temperature [°C], engine speed [RPM] and vehicle speed [km/h] were presented in the below figure.

According to the presented relations, the coolant temperature after the start of the vehicle reached the constant temperature of approx. 100°C. The engine speed depended on the vehicle speed and the highest value (2500 RPM) was achieved at the speed of 120 km/h. The rate of the power generated by the engine ranged between 0 (stopped vehicle) and 1 (maximum speed) and it amounted to approx. 0.5% over the most analysed distance.

The next calculated transients of the parameters obtained during the operation of the of "Combustion in engine" simulation block are respectively: air flow supplied to engine [g/s]; throttle position [%], distance travelled by vehicle [km], catalyst temperature [°C] and value of absolute power generated by engine [kW]. The analysis clearly shows that the air flow supplied to the engine increased with the travelled distance. The catalyst temperature reached its maximum value after approx. 200s and then remained at the constant level. The value of the absolute power generated by the engine increased with the lapse of time and the travelled distance.

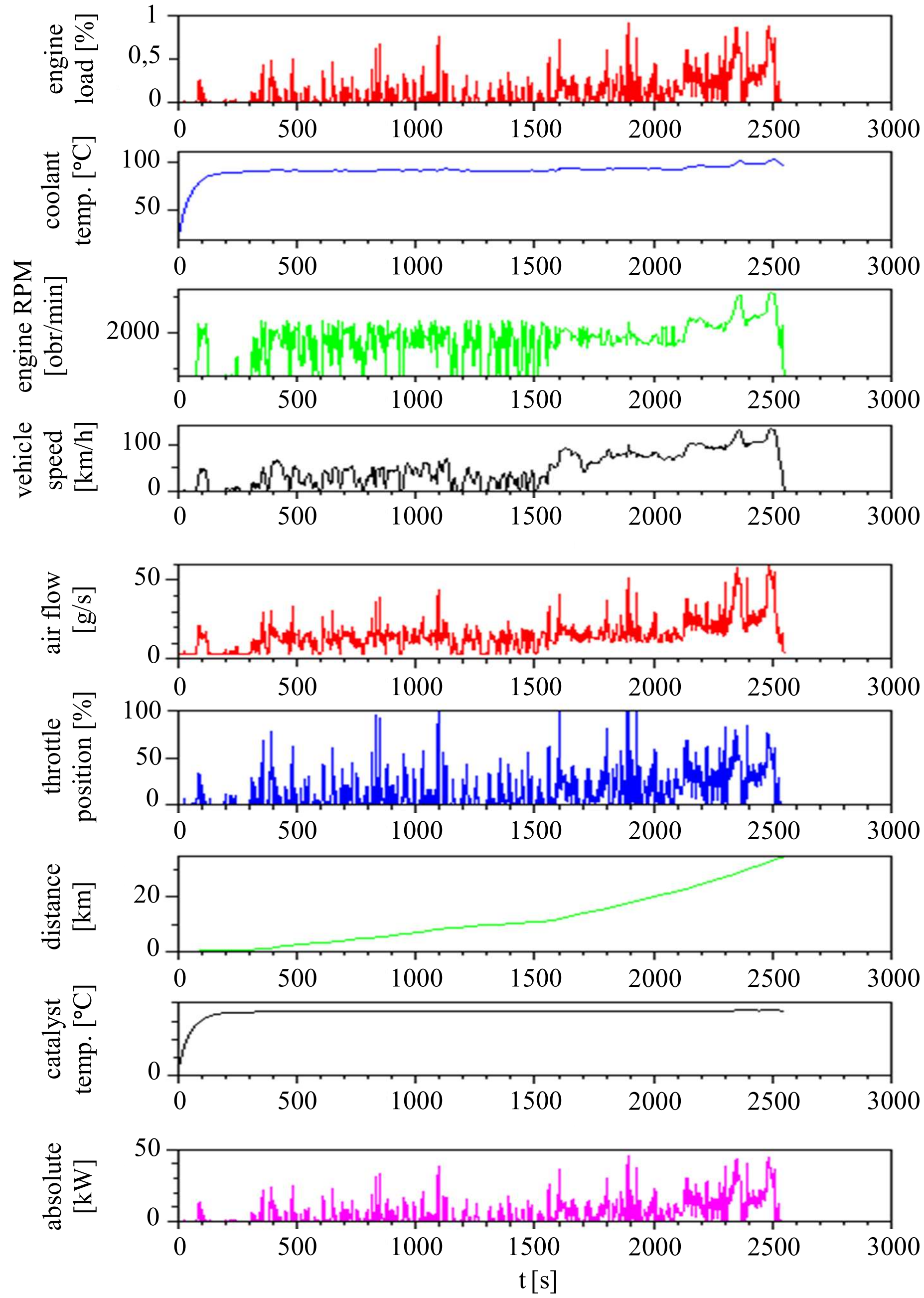

Figure 4. Operation results of "OBD" simulation block responsible for generation of data compliant with OBD standard for WLTP test

Conclusions

The electronic industry nowadays provides the consumers with a wide offer of the communication systems for the use in the modern vehicles in terms of transfer data rate, immunity to interference or implementation costs.

The mathematical relations were used to build a simulation model of the operation of the vehicle within the WLTP test which faithfully reproduces the real operating processes. The development of the simulation for the acquisition of the data on the current operating parameters of the engine allows for the creation of the programming solutions at the initial stages without the necessity for the operation of the programme with the real OBD system integrated in the vehicle.

The developed simulation should be extended in order to achieve the numerical models reproducing the real operating processes of the vehicle and the engine through the addition of the extra simulation blocks in an even more precise manner.

Proceedings
ISBN 978-609-449-148-1 (on-line)

References

ALIRAMEZANI, M., Koch, C.R., Patrick, R. 2018. Phenomenological model of a solid electrolyte NO_x and O_2 sensor using temperature perturbation for on-board diagnostics, Solid State Ionics, Vol. 321, 62-68.

BURELLE, C. 2004. On-Board Diagnostics II (OBDII) and Light-Duty Vehicle Emission Related Inspection and Maintenance (I/M) Programs, Transportation Systems Branch, Environment Canada.

CALABRESE, G. (Ed.). 2016. The greening of the automotive industry, Springer.

CAMPBELL, S. L., CHANCELIER, J.P., NIKOUKHAH, R. 2006. Modeling and Simulation in Scilab/Scicos with ScicosLab 4.4. New York: Springer-Verlag New York

DENTON, T. 2017. Automobile electrical and electronic systems, Routledge.

ELMAGHRABY, A. S., & LOSAVIO, M. M. 2014. Cyber security challenges in Smart Cities: Safety, security and privacy, Journal of advanced research, 5(4), 491-497.

FRENZEL L. E. 2016. Handbook of Serial Communications Interfaces. A Comprehensive Compendium of Serial Digital Input/Output (I/O) Standards. Chapter Twenty-Two: On-Board Diagnostics (OBD) II. 97-99.

LIM, L. L., ALPAN, G., & PENZ, B. 2014. Reconciling sales and operations management with distant suppliers in the automotive industry: A simulation approach, International Journal of Production Economics, 151, 20-36.

MAYYAS, A., QATTAWI, A., OMAR, M., & SHAN, D. 2012. Design for sustainability in automotive industry: A comprehensive review, Renewable and Sustainable Energy Reviews, 16(4), 1845-1862.

MCCORD, K. 2011. Automotive Diagnostic Systems: Understanding OBD I and OBD II, CarTech Inc.

NORTH, R. J., OCHIENG, W. Y., QUDDUS, M. A., NOLAND, R. B., & POLAK, J. W. 2005. Development of a vehicle emissions monitoring system, Transport: Proceedings of the Institution of Civil Engineers, 158 (3), pp. 167 - 177

PERCIVAL, R. V., SCHROEDER, C. H., MILLER, A. S., & LEAPE, J. P. 2017. Environmental regulation: Law, science, and policy, Wolters Kluwer Law & Business.

Poradnik Serwisowy 4/2010 Pokładowe systemy diagnostyczne OBD i EOBD (część 1)

POSADA F., BANDIVADEKAR A. 2015. Global overview of on-board diagnostic (OBD) systems for heavy-duty vehicles, White Paper. International Council on Clean Transportation: Washington

SKEETE, J. P. 2017. Examining the role of policy design and policy interaction in EU automotive emissions performance gaps, Energy Policy, 104, 373-381.

TOMIOKA, P., PIRES DE SOUZA, M. 2016. OBD-III: Tendencias e perspectivas. XXIV Simpósio Internacional de Engenharia Automotiva. Blucher Proceedings 3(1)

TSOKOLIS, D., TSIAKMAKIS, S., DIMARATOS, A., FONTARAS, G., PISITIKOPOULOS, P., CIUFFO, B., SAMARAS, Z. 2016. Fuel consumption an CO_2 emissions of passenger cars over the New Worldwide Harmonized Test Protocol. Applied Energy, vol. 179, 1152-1165

WIERZBICKI, S. 2003. Procedury diagnozowania pojazdów samochodowych zgodnych z normą OBD-II. Diagnostyka, vol. 28, 47-52

Data about the authors:

Karol Tucki, Warsaw University of Life Sciences, 166 Nowoursynowska St., 02-787 Warsaw, Poland
Remigiusz Mruk, Warsaw University of Life Sciences, 166 Nowoursynowska St., 02-787 Warsaw, Poland
Anna Bączyk, Warsaw University of Life Sciences, 166 Nowoursynowska St., 02-787 Warsaw, Poland
Katarzyna Botwińska, Warsaw University of Life Sciences, 166 Nowoursynowska St., 02-787 Warsaw, Poland