ISSN: 1231-4005
e-ISSN: 2354-0133
DOI: 10.5604/12314005.1137857

ELECTRONIC ENGINE CONTROL SYSTEMS IN MODERN VEHICLES IN ASPECT OF USING IT IN MILITARY COMBAT AND LOGISTIC VEHICLES

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Abstract

Because of much more restricted norms about polluting gas emission in modern vehicles, there is a need to make better control of fuel combustion. The process of fuel combustion is controlled by electronic control unit (ECU). The unit is analysing signals from many sensors, and when the control unit is not able to correct mistakes in fuel combustion, it turn on a warning indicator light and alarming a driver that the emission of polluting gas is too high. The problem is, that the hole system is undependable. The level of complicated of the system is high. In military vehicles, suddenly lost of power of an engine, because of some little mistake in emission control system, in combat conditions could be very danger. Off course, some armoured vehicles has special program in ECU, but most of the military vehicles are built on civilian vehicles, without any changes.

The paper show potentials danger in modern electronics controls units of engines. The authors has also practice not only in vehicles testing and service, but also in preparing sport vehicles for rally. The sports programs for ECU in rally vehicles, allows for example for drive with the full power of the engine, even if the temperature of the cooling system is very high, and in normal vehicles, the ECU would not allow to work in such a condition.

Keywords: *combustion engines, electronic control unit, military vehicles*

1. Introduction

The more and more stringent standards for combustion gas emissions by motor vehicles, introduced from time to time, cause that the modern engines are more and more complex. The designers of new engines install additional systems, reducing emissions of the most harmful combustion gas components, in order to meet new standards. As regards compression-ignition engines, it was made by increasing the fuel injection pressure and by dividing the main injection dose into several phases (Fig. 1). But currently the exhaust system, including filter systems – both solid and nitrogen oxide – is more and more extended and therefore it becomes more complex.

The current level of complexity of both the compression-ignition engine control system and more and more extended combustion gas treatment systems in exhaust system causes that there is probably no modern Diesel engine vehicle owner who is not periodically “harassed” by switched on engine light indicator, suggesting failure of any system. However, if in case of civil vehicles such switched on indicator causes, beside reduction of engine’s useful power, only some discomfort in vehicle operation, as regards military vehicles the sudden reduction of engine power in combat conditions may result in significantly more serious consequences, as for example the reduced dynamics of the vehicle may result that such vehicle will be hit by the enemy.

2. The example of vehicle provided with ECU

The vehicle chassis used for transporting the mobile laboratory for environment sampling and identification of biological dangers, installed in 30’ container, is a good example of vehicle provided

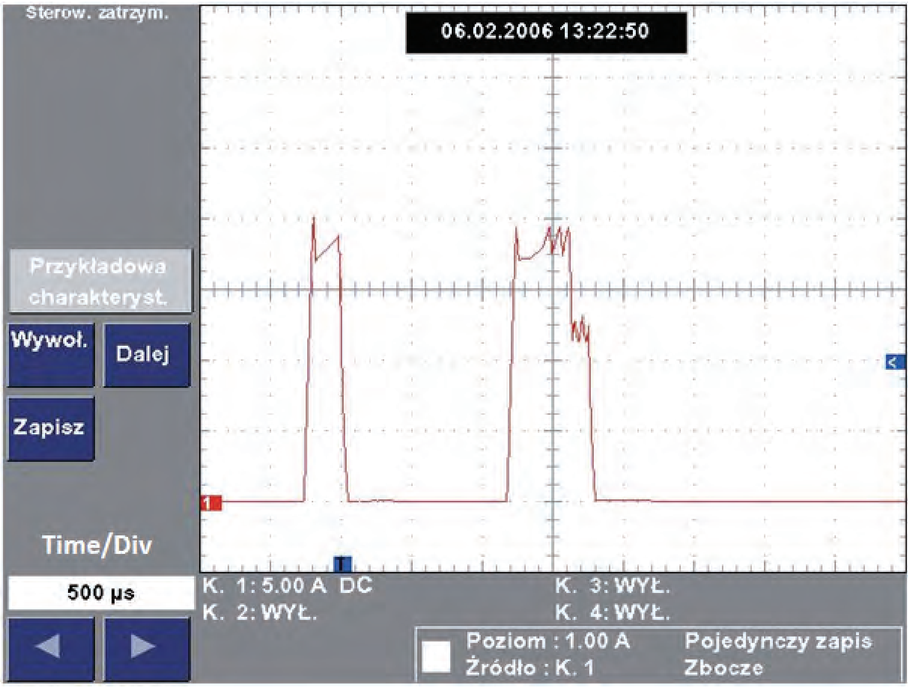

Fig. 1. The measurement of control current for common rail injection (measurement taken by authors). This diagram presents the preliminary injection and control current limit in the main injection phase (fig. – Piotr Stryjek WITPiS)

with Electronic Control Unit (ECU). This chassis is not designed especially for implementation to the Polish Army, it is only used for container's traction tests. Anyway, it is good example which allows to indicate the potential problems in operation of the modern vehicles by the Polish Army.

This chassis includes the Renault Premium truck-tractor and the container semitrailer (Fig. 2). The truck-tractor was provided with the 6-cylinders Diesel engine with common rail (CR) supply system. It shall be underlined now that this system is generally standard for cars, vans, trucks and it becomes popular in heavy duty vehicles. The supply systems with autonomous pumping sections are also used in trucks, among other things due to their higher hydraulic efficiency, we may assume that the common rail system will be the most common system in compression-ignition engines in the near future.

Fig. 2 The chassis and frame of container – final enclosure of the mobile laboratory (photo Paweł Włodarczyk WITPiS)

The common rail system structure is very similar for all manufacturers. This system includes pump which generates high pressure, reservoir of diesel oil under high pressure and injectors controlled by electric signal. The high pressure of fuel allows for its good spraying and possibly full combustion. It shall be noted that the maximum injection pressure has been increased by ten times in relation to designs of injecting pump banks used also in military vehicles STAR 266 (Fig. 3).

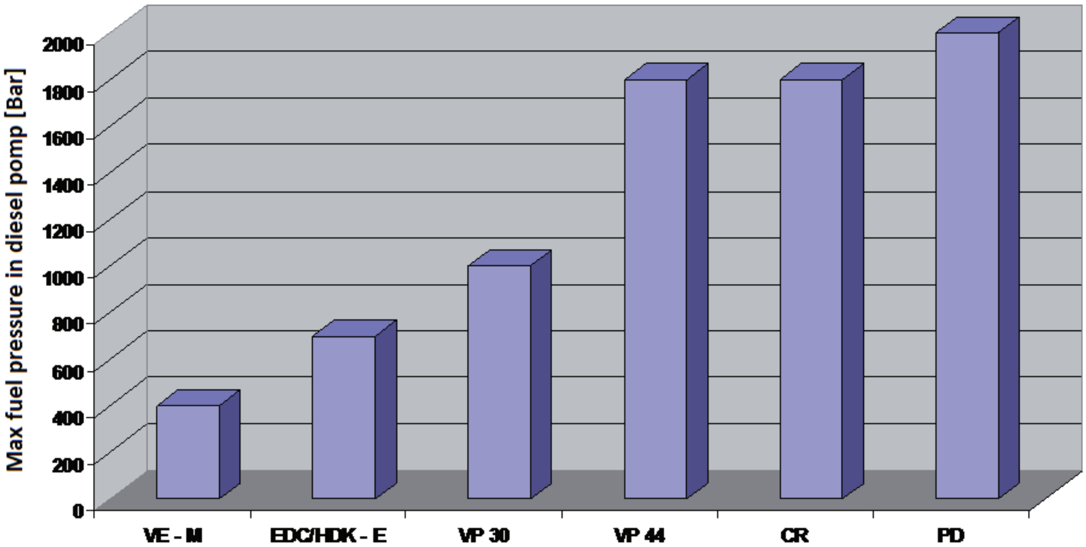

Fig. 3. The increase of maximum pressure in injecting systems – pump designations by BOSCH company types for car: VE-M – VP44 – distributor injection pomp, CR – common rail, PD – fuel injection unit VW group (fig. Piotr Stryjek)

The high pressure generated by pump's pumping sections is one of the highest dangers for the common rail system. The fuel oil is in them the only agent which lubricates the pumping components, operating under high load. When the sub-standard oil is used, it will cause very fast wearing of pumping components or even their damages. It is important insofar in case of military vehicles that we can not use many fuels for CR system – we can use only the high quality fuel oil. In case of older vehicles with strict row pumps, where part of pumping system was lubricated independently, the worse quality fuel oil or fuel oil and petrol mixture could be used in emergency or winter conditions. The possibility of water presence in oil and significant corrosion of injection system in case of long-term parking conditions, is an additional problem (Fig. 4). This problem is important insofar that special and combat vehicles are often subject to multi-months maintenance during which number of engine start-ups is restricted. According to authors' experience, the typical water catchpot in filters may not secure the injection system against corrosion in case of worse quality of fuel.

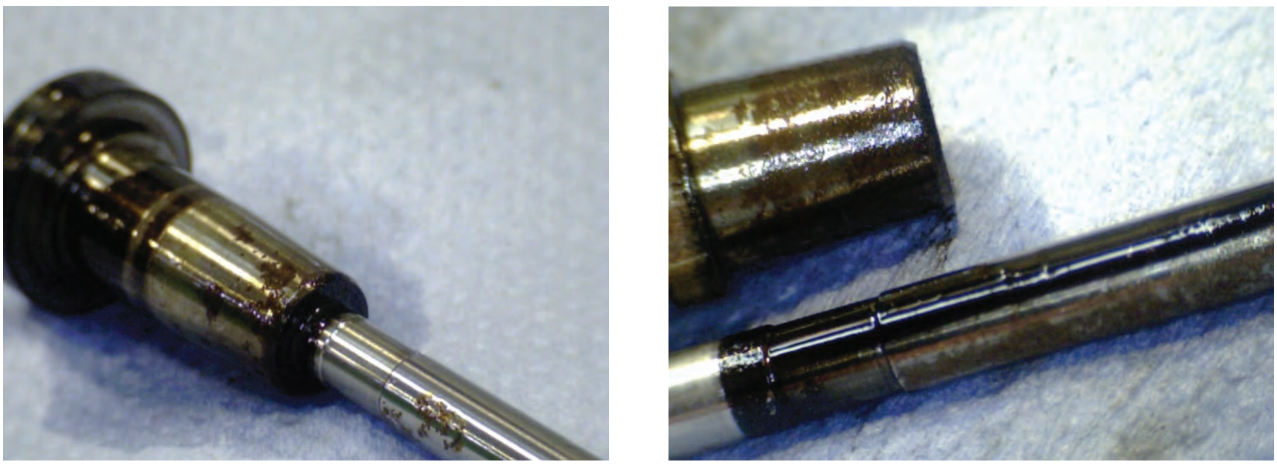

Fig. 4. The view of corrosion on components of injection system (photo Piotr Stryjek)

The combustion gas treatment systems in exhaust systems provide also many operation problems. The solids filters are often clogged even in civil vehicles operated in city conditions. The driving on short distances results in insufficient filter heating and impossibility of its efficient cleaning in high temperature. However, many special or combat vehicles are moved – outside periods on training ground – only on short distances within the military bases or they are operated in stationary mode (e.g. communication and command vehicles, where engine works in idle mode for most of the time).

In case of trucks, operation problems with AD-Blue system are frequent. This system is designed to reduce emission of nitrogen oxides, but it requires the specialist service and ad-bleu agent make up. In case of shortage of this agent, vehicle is switched into so-called emergency mode when its logistic properties, such as in case of described mobile laboratory carrier, or combat properties, are significantly reduced. When e.g. fuel oil is used instead of ad-blue agent in emergency situations, this results in its immediate failure (Fig. 5). It shall be stressed that most of vehicles in Polish Army is designed currently on civil chassis. Their engines are provided with entire instrumentation which allows them to meet the civil standard for combustion gas emission for the given type of engine.

Fig. 5. View of ad-blue agent leakage inside the pump enclosure (left), and application of e.g. fuel oil instead of ad-blue agent results in many designs in immediate damage of pump's rubber components (right) (Piotr Stryjek)

3. The technologies which increase reliability and mobility of military vehicles

The complexity of electronic systems in modern vehicles causes the many users and engineers are afraid to make even the most simple repairs in injection systems. At the first glance such impression seems justified looking at the seemingly complicated process of single fuel injection (authors' measurements on FIAT company 1100 cm^3 engine) in the most simple petrol engine with single-point petrol injection (Fig. 6). Anyway, in the author's opinion, good awareness of both positive and negative properties of the given technical solution is crucial for its proper operation. The electronic systems are provided with more and more sophisticated diagnostic systems, which allow for their wide usage not only for current repairs, even on the training ground [1], but they also support the entire operation process [2].

As for now, access to content of software of combustion gas controllers is relatively easy. Even the small, independent workshops can modify the so-called engine maps (Fig. 7) in order to increase its maximum output or to switch off e.g. filter service in exhaust system. The authors obviously do not support the software modification in the type approved vehicles, in particular concerning "by-passing" systems which provide low emission of exhaust gases, but we shall remember that in case of special, combat or fast response vehicles (buggy type vehicles), modification of engine software aimed to increase the maximum power or temporary switching off of systems reducing emissions of harmful components of exhaust gases may be appropriate.

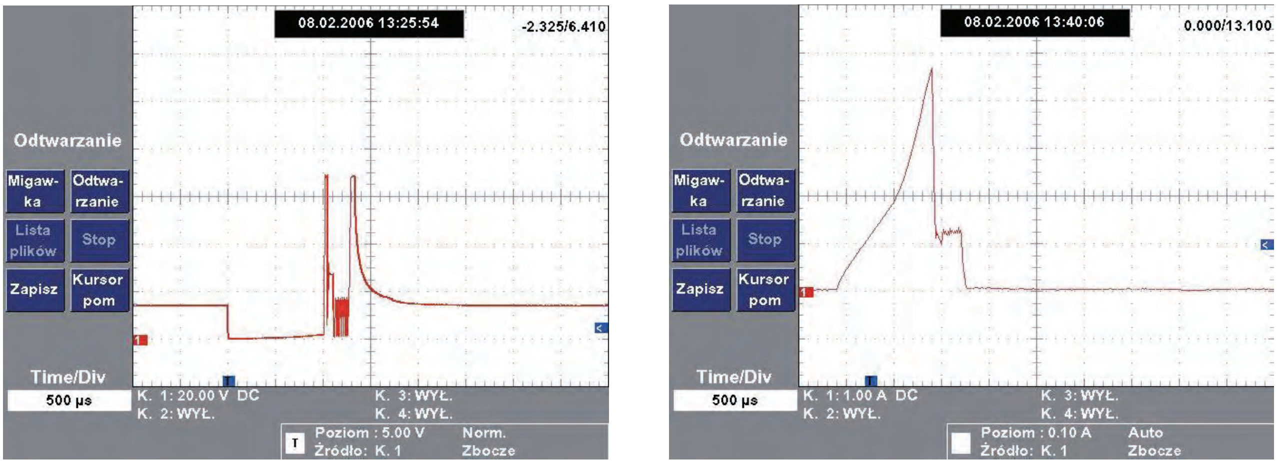

Fig. 6. The view of voltage (left) and current (right) which control the opening of the petrol injector needle. After the first needle raising pulse, the controller starts to time the voltage with hold the raised needle for injection period, which allows to reduce current from the engine controller power output. This operation is completed in engine even several dozen times a second (total injection time on idle run approx. 1.4 ms). The course of curves allows the skilled analyst for assessment of injector technical condition without any other special instruments (drawing and measurement – Piotr Stryjek)

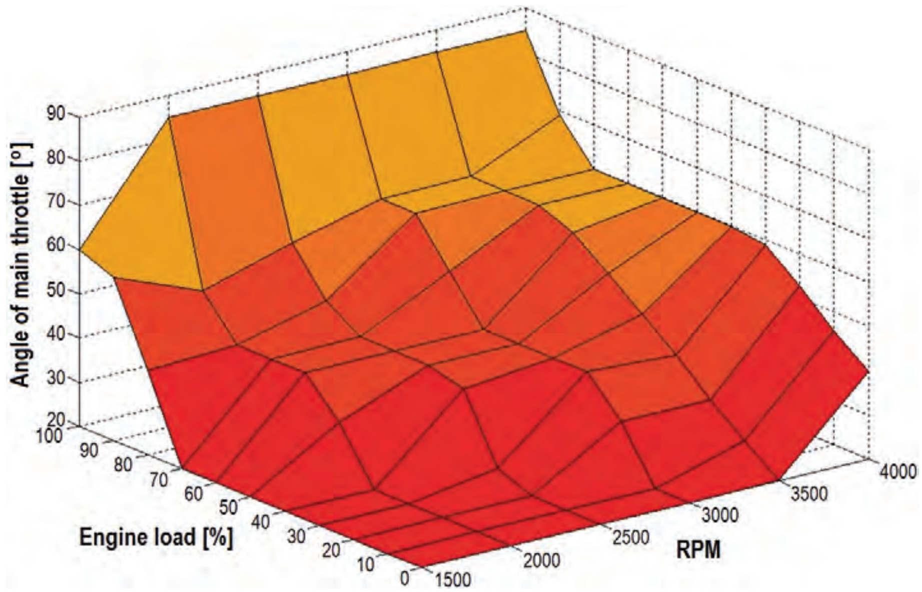

Fig. 7. The map prepared by the author of this paper which presents how the controller controls the main damper opening process in laboratory engine with mixture stratification (fig. Piotr Stryjek)

The armoured carrier KTO Rosomak is a good example for such solution. The engine's controller in this vehicle allows for two operation modes: in standard mode and so-called Overboost mode, where the engine reaches the higher power, so-called combat power. It is achieved at the expense of higher emission of individual exhaust gas components but, as tests revealed [3], in authors' opinion with acceptable values assuming the limited engine operation time.

The modifications of standard software or special computers instead of standard controllers, allowing for any combustion engine control process, are commonly used in motor sports (Fig. 8). Due to the specific usage of vehicle, similar as for combat vehicles, there is a possibility to raise the critical values at which the engine controller will reduce power in order to protect driving unit against damage or it is even possible to write such software to have control process by-passing sensors which are the most sensitive for damages. This allows for continued driving the rally vehicle at values of operation parameters (e.g. cooling liquid temperature) which would switch on so-called emergency engine operation mode and significant power reduction in "civil" vehicles.

Fig. 8. The view of armoured carrier KTO Rosomak (photo www.wzms.pl) and rally car (photo Paweł Jasicki); the modifications of engine control unit allow in both vehicles for correct operation even in heavy duty conditions

5. Summary

Analysing designs of modern military vehicles it can be noticed that some manufacturers start to perceive the potential operation problems connected also with systems which reduce emissions of harmful components of combustion gases in military operation conditions. Engines in some of the offered vehicles can work even when they have no liquid in Ad-Blue system. However, there is still no exact requirements for strategy of combustion engine operation control in military vehicles in combat conditions and the military decision makers are often condemned for factory chassis proposed by big automotive companies without ability to influence on level of sophistication of control electronic systems. This may result in operation problems in the future.

As military vehicles are operated in majority of their operation life in peace conditions, reduction of their negative impact on environment shall be the priority. However, as is presented in this paper, it is possibility to improve operation parameters of combustion engine when the human life and e.g. ability of efficient evacuation from combat field are more important than emission of combustion gases or possibility that some engine units will be damaged.

Acknowlegdements

The study financed from polish Ministry of Science and Higher Education project No. O ROB/ 03101/ID31/1 entitled *Mobilne laboratorium do poboru próbek środowiskowych i identyfikacji zagrożeń biologicznych*.

References

[1] Stryjek, P., *Diagnozowanie pojazdów wojskowych wyposażonych w elektroniczne układy sterujące w warunkach poligonowych*], Materiały z Symposium Eksplolog 2008, pod redakcją Kazimierza Kowalskiego [*The Diagnostic of Military Vehicles Provided with Electronic Control Systems in Training Ground Conditions* Materials from Symposium Eksplolog 2008, edited by Kazimierz Kowalski], WSOWL Wrocław 2008.

[2] Merkisz, J., Pielecha, I., Pielecha, J., Szukalski, M., *Możliwości oceny warunków eksploatacji KTO Rosomak na podstawie pokładowych systemów diagnostycznych*, Zeszyty Naukowe WSOWL, Nr 4 (158), [*The Possibilities of Assessment of KTO Rosomak Operation Conditions on the Base of On-Board Diagnostic Systems*, Scientific papers WSOWL, No. 4 (158)], 2010.

[3] Merkisz, J., Pielecha, I., Pielecha, J., Szukalski, M., *Emisja spalin z wozów bojowych Rosomak w warunkach poligonowych*, Zeszyty Naukowe Akademii Marynarki Wojennej, Rok LII, Nr 1 (184) [*The Emission of Combustion Gases from ROSOMAK Combat Carriers in Training Ground Conditions*, Scientific papers of the Military Navy Academy, Vol. LII, No. 1 (184)], 2011.