FACTA UNIVERSITATIS
Series: **Automatic Control and Robotics** Vol. 15, N° 1, 2016, pp. 1 - 7

RESEARCHING THE WAVEFORMS OF THE AUTOMOBILE ELECTROMAGNETIC ACTUATORS

UDC ((681.518.52+537.86):621.114.6)

Slavcho Bozhkov[1], Ivan Milenov[2], Ognian Slivarov[3], Gergana Staneva[4], Penko Bozhkov[5]

[1,3]University of Plovdiv, Technical College Smolyan, Smolyan, Bulgaria
[2]Todor Kableshkov University of Transport, Faculty of Telecommunication and Electrical Equipment in Transport, Sofia, Bulgaria
[4]University of Rousse, Department of Engines and Transport Engineering, Rousse, Bulgaria
[5]Olimex Ltd, Plovdiv, Bulgaria

Abstract. *This paper considers the signal waveforms of the control system of the automobile and automobile engines, their specific regions and possibilities of diagnostics and evaluation. The actuators signals, which are represented by waveforms, are an object of research for obtaining feedback for the condition of the processes and devices, which are the sources of these signals. The analysis of the waveforms is the precondition for diagnostics of the systems, into which these devices are integrated.*

Key words: *actuators, automobile, electromagnetic, waveforms, researching.*

1. INTRODUCTION

The most of the electromagnetic actuators applied in the modern automobiles are based on the electromagnetic principle. Such devices are electromagnetic coils, electromagnetic valves or stepper motors. These actuators are controlled by signals from the electronic control unit (ECU) and powered mainly the linear and rotation moving of the control automobile devices. Their output parameters are the electric signals or mechanical movements, which are directed to the designated device of the automobile systems [5].

Received December 07, 2015
Corresponding author: Slavcho Bozhkov
University of Plovdiv, Technical College Smolyan, 28 Dicho Petrov Str., 4700 Smolyan, Bulgaria
E-mail: slavcho_bozhkov@yahoo.com

Each signal or movement has its own specific waveforms and its deviation may be counted as a sign of malfunction that occurred in the system watched by the sensor or in the sensor itself [1]. The deviation of the automobile actuators parameters depends as the rule on its technical conditions and lifetime.

The article renders some specific automobile electro-magnetic actuators waveforms and the possibilities for applying them in automobiles diagnostics.

2. EQUIPMENT

For the present research there are used standard and specialized tools for measuring and diagnostics with the main aim to receive live signal waveforms, which can be observed, processed and memorized in a database and used for the next analysis and evaluation.

The automobile electromagnetic actuators are used to perform a special task in engine and automobile control systems, such as fuel and ignition system, emission tuning system, auxiliary equipment, etc.

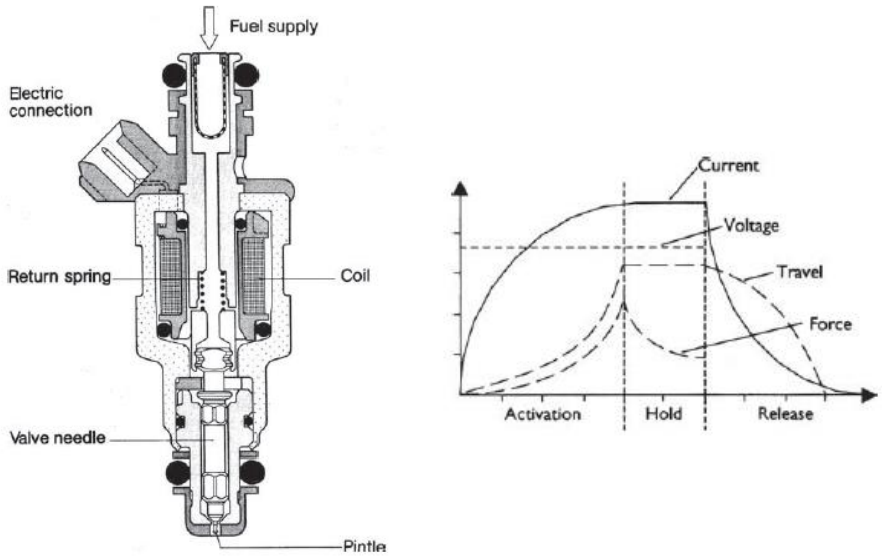

Fig.1 Electromagnetic injection valve

These actuators are of electromagnetic type and have two modifications: electromagnets and electro-motors. They consist of a determined number of coils (or coils and permanent magnets) in which there is generated the EMF by the control power signal from the automobile electronic control unit. The schemes of these actuators are shown in Fig.1 [3], Fig 2 and Fig. 3 [2].

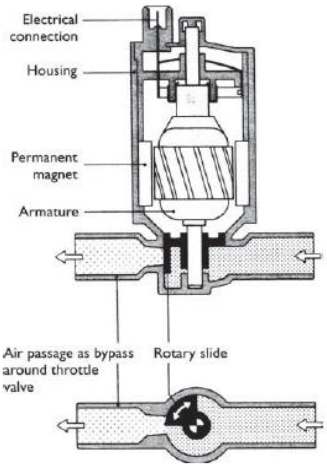

Fig. 2 Electromotor idle air control actuator

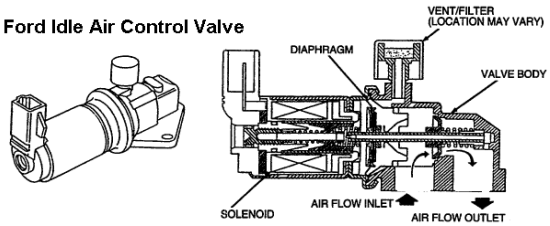

Fig. 3 Electromagnetic idle air control actuator (source Ford media)

In this way are observed live actuators signal waveforms, which control engine fuel and ignition systems. The obtained results are recorded in the database and used for the diagnostics of the automobile and its systems.

The measuring and observing of the waveforms of the automobile actuators is realized by the specialized automobile digital oscilloscope, with technical data pointed in [5].

For the research of automobile electromagnetic actuators is used laboratory equipment SV-1 (fig.4). The equipment SV-1 is based on the Motronic fuel system developed from Bosch and has combined injection and ignition systems controlled by the electronic control unit type M 1.7.2. The actuators of the equipment SV-1 are ignition coils, injectors and idle speed control valve.

Fig. 4 Equipment SV-1

3. APPLICATION

With the above pointed equipment particular experimental data are obtained, which give an initial idea for the application and the analyzing of the automobile electromagnetic actuators parameters for diagnostics and control of the automobile technical condition.

The modern petrol ICE is equipped with electromagnetic actuators for the control of the idle speed, exhaust gas re-circulation, boost control, etc.

These actuators are controlled by ECU signals and they operate the valves (elements), which adjust the correct mixture. The actuators are built from magnetic coils and the electromagnetic force determines the movement of their control element, which is excited by the EMF of the ECU control signals. The EMF creates a back EMF and its influence above the actuators and ECU may be explained by its waveform.

In Fig. 5 is represented the start process of the automobile electromotor idle speed actuator and in Fig. 6 – the end process.

The difference between the two signal waveforms is determined by the back EMF and it has specific parameters such as waveform, amplitude and frequency. These parameters are used to determine the correct technical condition of the actuators, i.e. of the automobile system.

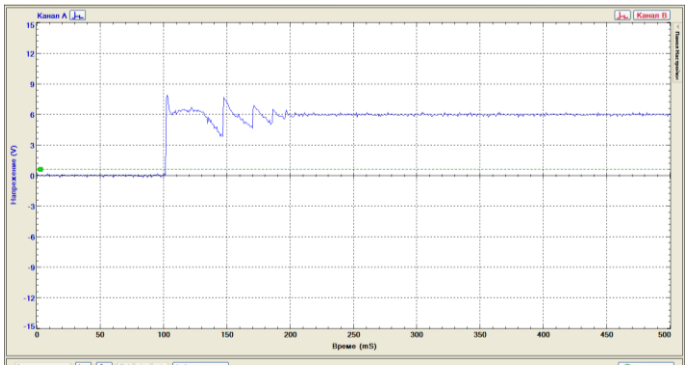

Fig. 5 Electromotor IAC actuator signal waveform – start process

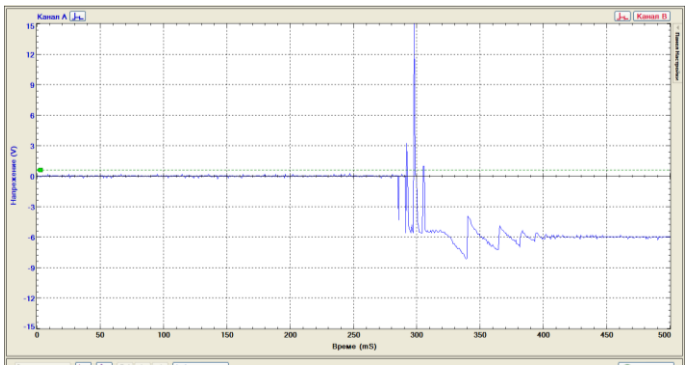

Fig. 6 Electromotor IAC actuator signal waveform – end process

In Fig. 7 is represented the single control signal waveform to the automobile electromagnetic idle speed actuator.

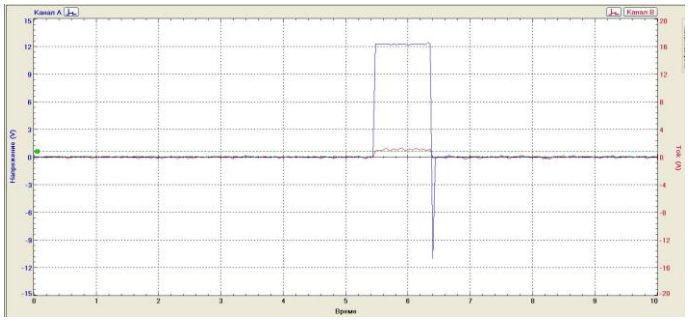

Fig. 7 Electromagnetic IAC actuator signal waveform – start process

The amplitude value of (including the back EMF voltage) which is observed in these two actuators is almost the same and equal to double power voltage, i.e. 24 V.

In Fig. 8 is represented the variation of the gasoline injector signal waveform at the start of the engine of equipment SV-1 (with use of 1:20 attenuator).

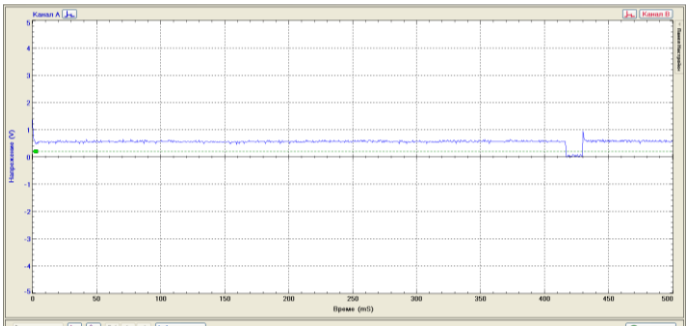

Fig. 8 Variation of the gasoline injector waveform at the start of the SV-1 engine

The pulse time is approximately 20 ms. This injection time is very long and is required for injection of extra fuel during the start process of the SV-1 engine. This process is similar for almost every automobile engine. The amplitude of back EMF voltage is approximately 20 V.

During the acceleration of the SV-1 engine the injection time is changing according to the program data recorded in the ROM of ECU. The type of ECU is Bosch Motronic MED M1.7.2, which is a typical example of most automobiles.

Fig. 9 shows the variation of the gasoline injector signal waveform during the process of acceleration. The amplitude of back EMF voltage in this case is approximately 60 V and more, which is 3 times more than in other processes.

The reason for this increased back EMF voltage according to us is the increased frequency of gasoline injector signal waveforms.

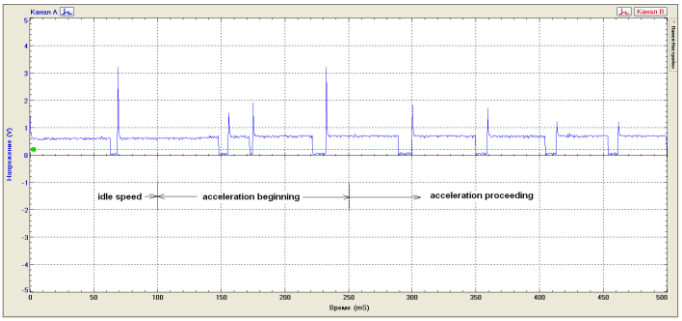

Fig. 9 Variation of the gasoline injector waveform at the start of the SV-1 engine

Another automobile actuator is firing coil. It consists of two windings. In the first winding flows the current, which is controlled by the ECU, and in second high voltage is induced, which makes the spark from the spark plugs.

The current in the first winding, in most automobiles is controlled via a transistor unit and there should not be high back EMF voltage during the coil commutation.

Fig. 10 shows such firing coil signal waveform variation during a certain engine mode of equipment SV-1. As shown there are not high values of the back EMF voltage.

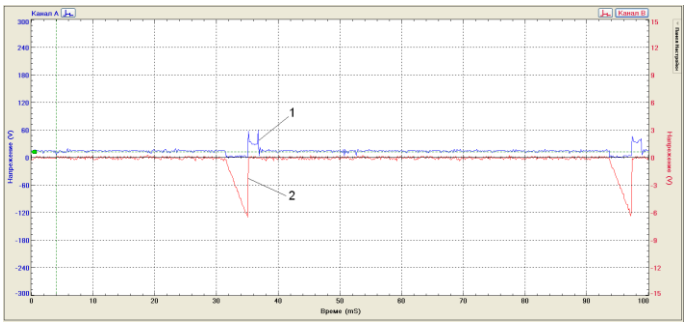

Fig. 10 Variation of the firing coil first winding waveform: 1-current signal waveform of the firing coil; 2-high voltage signal waveform

However, as reviewing the record of the signal wave-form is observed, there are some moments of the high back EMF voltage with amplitude approximately 300V for 0,5 ms (fig.11).

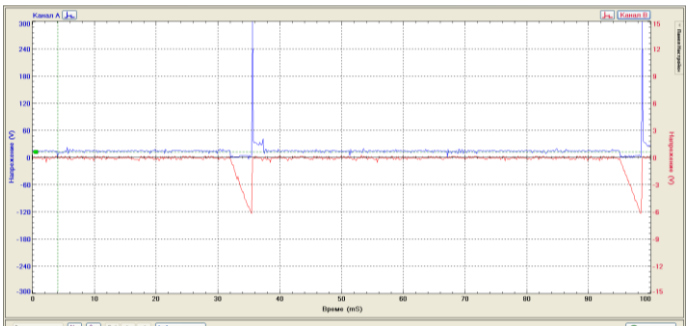

Fig. 11 Variation of the firing coil first winding waveform: 1-current signal waveform of the firing coil; 2-high voltage signal waveform

This fact is explained according to us with the reaction time of the transistor unit, which can vary in certain limitations. And when this time is long enough to permit the back EMF voltage generation the result is the high back EMF voltage.

4. CONCLUSION

The initial derived records of the automobile electro-magnetic actuators waveforms ensure an opportunity for a comparative analysis and diagnostics of the automobile technical condition.

The results are explained the application and the features of the electromagnetic automobile actuators, which are used in automobiles.

Acknowledgement: *The paper is a part of the research done within the project agreement № НИ15-КС-016/24.04.2015 and agreement № СП15-КС-010/24.04.2015. The authors would like to thank to the Plovdiv University "Paisii Hilendarski" for funding the projects.*

REFERENCES

[1] Aird F., *Bosch Fuel Injection Systems*, HP Books – Berkley Publishing Group, New York, 2001.
[2] Denton T., *Automobile electrical and electronic systems*, Elsevier Butterworth-Heinemann, Oxford, 2004.
[3] Denton T., *Automobile mechanical and electrical systems*, Elsevier Butterworth-Heinemann, Oxford, 2011.
[4] S. Bozhkov, I. Milenov, A. Gozmanov, G. Staneva, P. Bozhkov, "Researching the signals of the automobile electromagnetic actuators", in *Proceedings of 12th International Conference on Applied Electromagnetics - PEC 2015*, Niš, Serbia, 2015.
[5] http://env.dipseil.net/v3/editor/courses.php - automobile electronic and computer systems
[6] http://obd2-bg.com/mScope/index.html – automobile oscilloscope and attachment