

# EQUIPMENT CB-1 FOR RENDERING THE PERFORMANCE OF THE ICE WORKING WITH GASOLINE INJECTION FOR RESEARCH AND EDUCATIVE-APPLIED AIM

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**Abstract:** *In this paper are described the results about designing of set CB-1 for rendering the work of the injection ICE with aim to scientific research and application of the results, as well introducing the student with their features during the labs.*

**KEYWORDS:** AUTOMOBILE, ENGINE, EQUIPMENT, RESEARCH, RESULT, STUDENTS

## 1. Introduction

The article concerns the results during the developing of equipment CB-1 for rendering the performance of ICE, working with gasoline injection. The main objective of CB-1 is ensuring the possibility for visualization, measuring and diagnostics the engine parameters for researching and educative-applied aim.

One method to improving the fuel consumption end ecology of ICE is optimizing the fuel dosage and distribution according to the work mode and work condition of the engine [1].

Moreover the significant influence of the exploitation factors is observed, such as quality and type of the fuel, technical condition of the engine and its system elements, specific moments during the technical servicing and using the elements with ill-matched characteristics and etc.

This determines the researching of the influence of these factors upon the optimal performance of the engine and specifying the relevant dependences, which to be used as base point to control and evaluate its technical condition.

## 2. Description and principle of work of the equipment CB-1 for rendering the performance of ICE, working with gasoline injection

The common view of the developed equipment is presented on the fig.1.

The equipment elements are mounted on the base 1, which ensures uniformly load distribution by six supports with vibrate-isolating rubber pads.

The starting of the engine 5 of the equipment is realizing by the ignition key placed in the control panel 7, which is containing the electronic control unit (ECU), the dashboard and the diagnostic socket.

The fuel is storing in the fuel tank 2, placed in the lower part of the base.

The controlling and changing the ICE revolution is doing by the lever 6, linked with the engine throttle. To the throttle housing by the stand is mounted the mass airflow meter together with the air filter 4.

The exhaust system 8 of the equipment is considered according to the modification and type of the engine.

The accepted layout of the equipment ensures the necessity visualness of the working process of the separate engine systems and its elements at keeping the requirements of safety and access for measuring and diagnosing.



Fig.1. Common view of equipment CB-1 for rendering the performance of ICE, working with gasoline injection:

1-base; 2-fuel tank; 3-radiator; 4-air filter and mass air flow meter; 5-engine; 6-throttle lever; 7-control panel; 8-exhaust system

## 3. Specification of the measuring and diagnostic tools

During the process of visualization and researching the performance of the equipment CB-1 are using standard and specialized tools for measuring and diagnostics. The main aim is to receive live data and graphics, which can be observed, processed, memorized and reopened for analyze and evaluating.

The measuring and observing the alternative signals is realizing by the specialized automobile digital oscilloscope, which have the following technical data [2]:

- Number of channels: 2;
- Number of outer synchronization: 1;
- Input impedance:  $1\text{M}\Omega / 25\text{ pF}$ ;
- Input voltage range:  $\pm 1\text{V}; \pm 2\text{V}; \pm 5\text{V}; \pm 10\text{V}; \pm 15\text{V}$ ;
- Maximum input voltage:  $\pm 400\text{V}$ ;
- Computer connection: USB 2.0;
- Power for the adapter: from the USB;
- ADC: 8 bits;
- Frequency band: DC up to 100 kHz (up to 10  $\mu\text{s/mark}$ );
- ADC frequency: 200000 per 1 s;
- Synchronization: automatic; single; outer; AC/DC; by increasing and by decreasing frontage;
- Record mode.

The measuring of the current signals to the actuators (injectors, electromagnet valves, coils, relays etc) is doing by current clamps type CA-60 with the following data:

- Measuring current: DC/AC from 10mA up to 60A;
- Frequency: up to 20kHz;
- Measuring accuracy: 1mV/10mA (100mV=1A) DC/AC from 10mA up to 20A; 1mV/100mA (10mV=1A) DC/AC from 20A up to 60A;
- Temperature accuracy: 0.1x(measuring accuracy) per degree °C.

The measuring of the high currents (starting the engine) is realizing by the current clamps type CA-600 with the following data:

- Measuring current: DC/AC up to 600A;
- Frequency: up to 400Hz;
- Measuring accuracy DC signals: 1mV/1A  $\pm(2\%+2A)$  from 0 up to 600A;
- Measuring accuracy AC signals (from 50 up to 400Hz): 1mV/1A  $\pm(2\%+2A)$  0~400A;  $\pm(3\%+2A)$  400~500A;  $\pm(6\%+2A)$  500~600A;
- Temperature accuracy: 0.1x(measuring accuracy) per degree °C.

The pressure pulsations are converting to the suitable signal to the automobile oscilloscope by the pulse sensor.

The primary voltage of the ignition system, as well as the control signals to the injectors (or actuators) is measuring by the transformer 20:1.

The secondary high voltage produced from the ignition system is measuring by the capacitive sensor. These pointed above tools are referred to the specialized tools of the equipment CB-1.

The engine system pressure (fuel, oil, coolant etc) is measuring by the set of manometers, vacuum-meters and their relevant attachments and adapters.

The engine compression is measured by the specialized arrow compression-meter with relevant adapter.

To perform the diagnostic pressure test is used the specialized vacuum pump, which produce pressure to 4,0 bar and vacuum to 40 in Hg.

The measuring of the temperature (oil, coolant etc) is performing by the Hg thermometer range 0-200°C with suitable connector.

The connection to the ECU is doing by the diagnostic socket, to which is plugged the specialized diagnostic interface with specific software according to the equipment engine. By this way are observed live data, as the revolution, temperature, pressure, fuel consumption, air consumption, ignition advance etc, as well as is performed the diagnostics of the engine and its systems.

#### 4. Some results from the equipment CB-1

At the initially developing of the equipment CB-1 are received the experimental results and characteristics, which represents the technological possibilities of the CB-1 as well as the applied tools for measuring and diagnostics.

On the fig.2 is presented the waveform of pressure in the engine manifold (curve 1) and of the signal from the crankshaft position sensor (curve 2). The vertical *a* means TDC of crankshaft determined by the signal from crankshaft position sensor, and vertical *b* – by the moment of shutting of the inlet valves. The difference between them can be used to evaluate the technical condition of the valve-train.

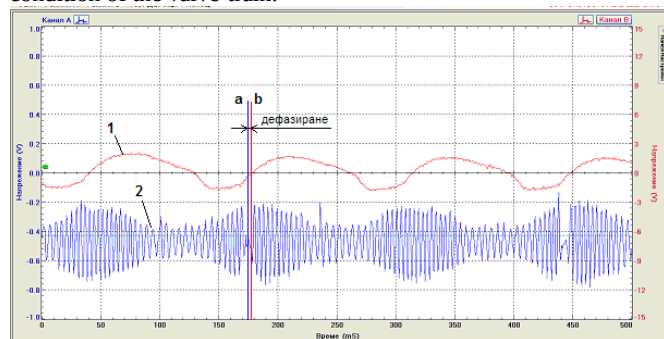


Fig.2. Graphics of the valve-train process:

1-pressure in the engine manifold; 2-signal from the crankshaft position sensor

From the fig.3 to fig.6 is presented the starting process of the engine, which is consisted from the following stages: turning on the ignition key (fig.3), turning on and putting in motion of the starter (fig.4), putting in motion of the crankshaft and exciting of the alternator (fig.5) and actuating of the voltage regulator when the engine has already started (fig.6).

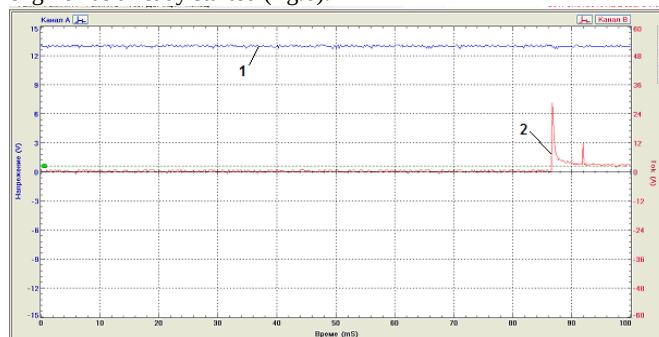


Fig.3. Turning on the ignition key:  
1-voltage signal; 2-current signal

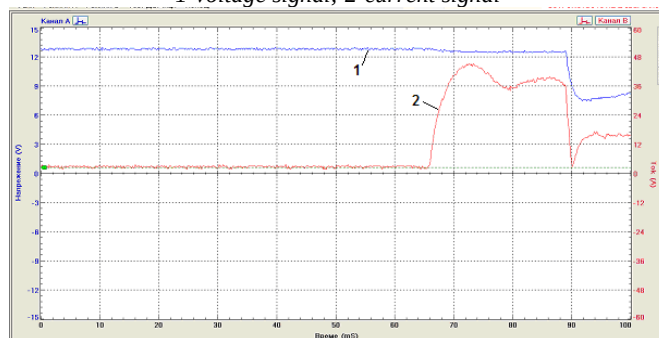


Fig.4. Turning on the starter:  
1-voltage signal; 2-current signal

Thus can be made evaluation about the very starting process as well as about the performance of the alternator and voltage regulator. The curves 1 describe the voltage, and the curves 2 – the current.

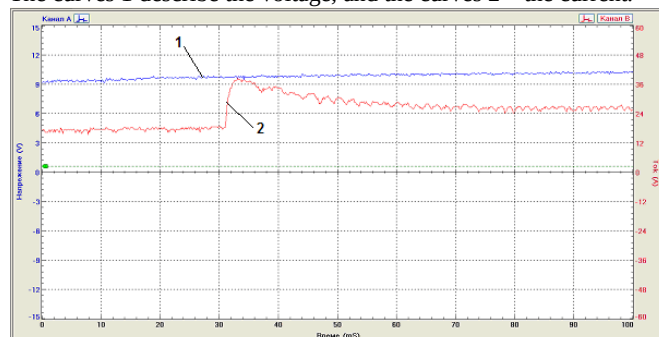


Fig.5. Putting in motion of the crankshaft and exciting of the alternator:  
1-voltage signal; 2-current signal

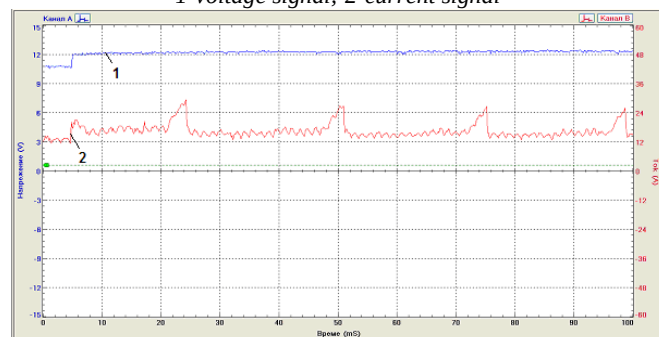


Fig.6. Putting in motion of the engine and actuating of the voltage regulator:  
1-voltage signal; 2-current signal

At the fig.7 and fig.8 is presented the starting process of cold (10°C) and warmed (90°C). In this case the measured value of the starter

current of cold engine is  $I_{st}=170A$ , and of warmed engine –  $I_{st}=195A$ .

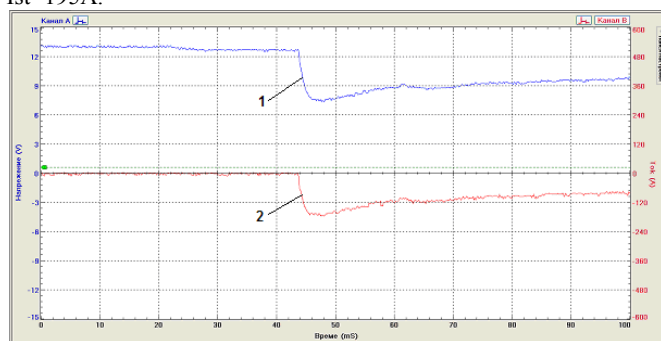


Fig.7. Starting the cold engine:  
1-voltage signal; 2-current signal

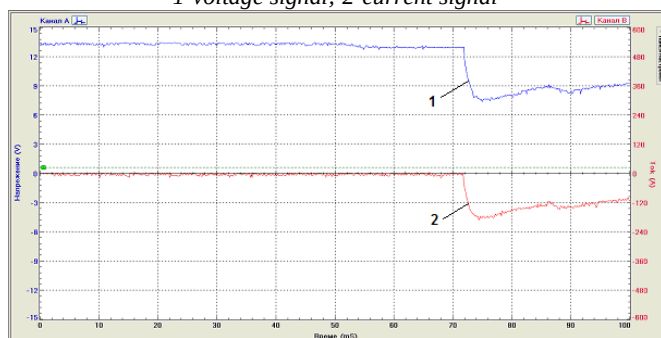


Fig.8. Starting the warmed engine:  
1-voltage signal; 2-current signal

By the value of the starter current in starting mode can be made evaluation about the engine compression and worn-out of its piston-cylinder group. The measured values can be written in the database for relevant engine (automobile) and to be used during the next measuring as the base for comparison and evaluation.

From the fig.9 to fig.11 are presented the work processes of the ignition system of three different revolution modes of the engine (without applied load), as following:  $n=850 \text{ min}^{-1}$  – idle mode (fig.9),  $n=2000 \text{ min}^{-1}$  (fig.10) i  $n=3000 \text{ min}^{-1}$  (fig.11). The curve 1 presents the signal from the crankshaft position sensor, and curve 2 – the high voltage signal to the ignition plug.

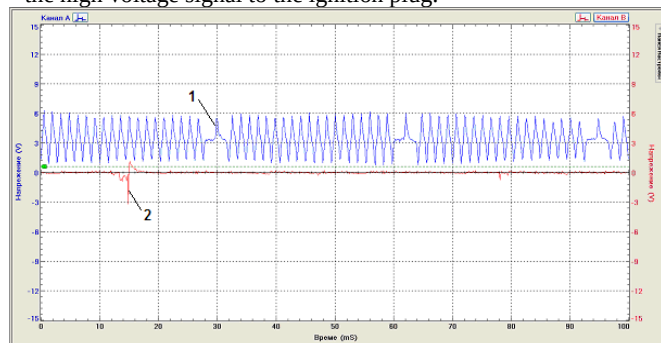


Fig.9. Working process of the ignition system at  $n=850 \text{ min}^{-1}$ :  
1-signal from crankshaft position sensor; 2-secondary high voltage signal

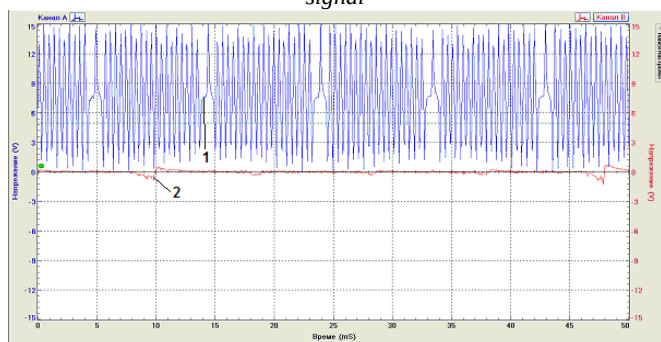


Fig.10. Working process of the ignition system at  $n=2000 \text{ min}^{-1}$ :  
1-signal from crankshaft position sensor; 2-secondary high voltage signal

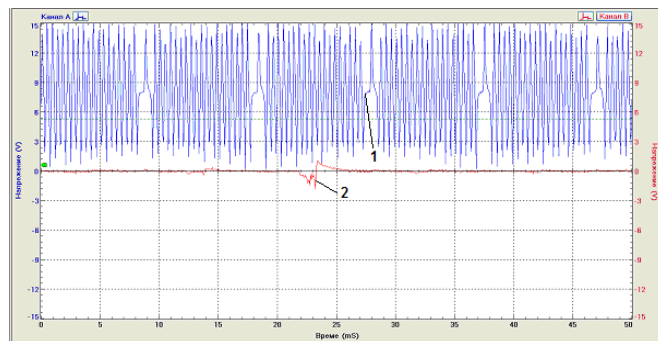


Fig.11. Working process of the ignition system at  $n=3000 \text{ min}^{-1}$ :  
1-signal from crankshaft position sensor; 2-secondary high voltage signal

The retrieved waveforms can be used for analyze the spark parameters (breakthrough voltage, sparking continuance), as well as for determine the ignition advance during the different working modes. Thus is realized the marks for analyze and diagnostics of ignition system and its elements.

The more closely researching of the spark create processes is presented on the fig.12, which describes the primary voltage (curve 1) and the secondary voltage (curve 2) of the ignition system. On the fig.13 is shown the waveform of the spark components – capacitive spark with sharp pike and voltage  $U_{breakthrough}=10,2 \text{ kV}$  and inductive spark with sloping section and smooth pike and  $U_{breakthrough}=1,8 \text{ kV}$ .

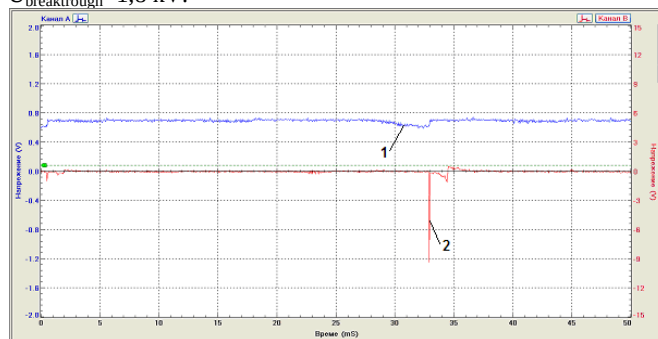


Fig.12. Waveforms of the primary and secondary voltage of the ignition system ( $n=850 \text{ min}^{-1}$ ):  
1-primary voltage; 2-secondary voltage signal

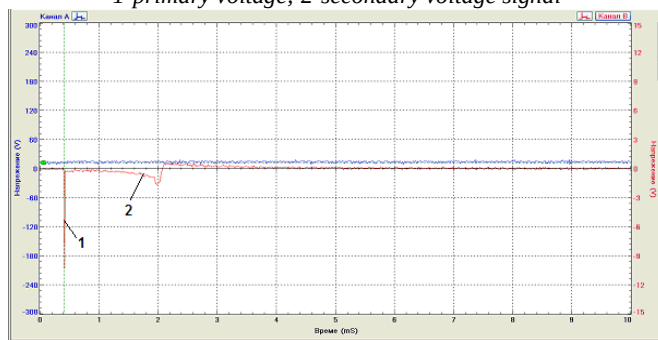


Fig.13. Waveform of a single spark ( $n=850 \text{ min}^{-1}$ ):  
1-capacitive section; 2-inductive section

A possibility for measuring, analyze and diagnostics the engine condition is presented on the fig.14 by the waveform from the oil pressure sensor. A definite interest has the section 3 (pulsations at the engine starting) and section 6 (pulsations at the engine stopping).

The pressure pulsations in these transitional sections can be used as marks for relative evaluation about the windage between rubbing couples. The recording of these data in a database can be used as mark for comparison at the next control and service of the same engine (automobile) after the certain mileage.

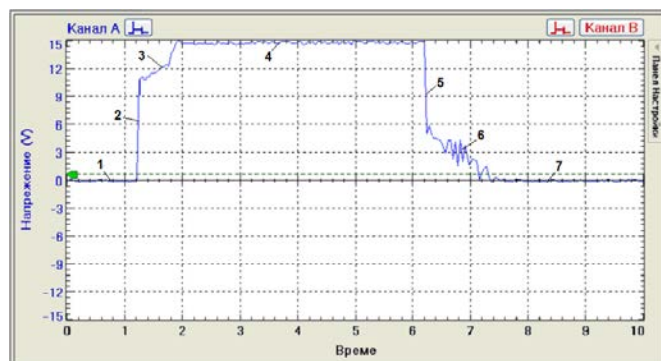


Fig.14. Waveform from the oil pressure sensor:

1-engine stopped; 2-engine starting; 3-pulsations at the start; 4-engine work; 5-engine stopping; 6-pulsations at the stop; 7-engine stopped

## 5. Conclusion

1. The developed laboratory equipment CB-1 for rendering the performance of ICE, working with gasoline injection ensures possibility for observing, measuring and diagnostics of the running working processes.
2. The initially retrieved experimental results of CB-1 working are the mark for comparative analyze and evaluation of the engine technical condition and its system, as well as for the continuing of these researching with aim to retrieving the specific and interesting results relevant to determine working modes.

## Literature

1. Dimitrov P. Systems for control the processes in the internal combustion engines, TU\_Sofia, Sofia, 2007.
2. <http://obd2-bg.com/mScope/index.html> – automobile oscilloscope and attachments.