ACTUATING AND DATA ACQUISITION SYSTEMS USED IN CASE OF A TEST BENCH FOR TESTING ENGINE VARIABLE VALVE TIMING SYSTEM ELECTROVALVES

[1]Anghel Chiru [*], [2]Silviu-Florian Săraru, [3]Eduard Golovatai-Schmidt

[1] Transilvania University of Braşov, [2],National Institute of Forensic Expertise, Bucharest, [3]Schaeffler Technologies GmbH &Co. KG, Germany

KEYWORDS – Test Bench, Electrovalves, Variable Valve Timing, Actuating, Data Acquisition

ABSTRACT – The article presents the actuating and data acquisition systems used in case of a test bench designed and manufactured for studying contaminantion behaviour of some components of the vehicle engine variable valve timing system.

Particulary, a concept integrates all the equipment and software used for the test bench were in detail presented. This concept system includes different type of sensors, data acquisition board with dedicated software programs, integrated board for actuating electro-valves tested particulary developed, and many other devices.

In conclusion, all these were used from the necessity of studying the contaminants behaviour of the electrovalves of the Vario Cam Plus system, with the eye of a future improvement, because a proper function of these components means optimal behaviour of the vehicle engine, like fuel consumption reduction, polluant emission decrease, and engine performance improvement.

MAIN SECTION – A test bench was developped at the Transilvania University under the guidance of Schaeffler KG Germany, in order to study the lifetime of some electrohydraulic valves, component parts of a variable valve timing system, which are influenced by contaminated particles from the engine oil.

During the flowing process, due to entering the particles from the contaminated oil between the moving parts of the valve, is influenced their normal operation (by blocking parts), eventually resulting valve failure.

As a result, may be assumed that the role of the electrohydraulic valve as part of the variable valve timing system is essential, requiring the need for better monitoring on a test bench to be developped (figure 1).

On the test bench were integrated some monitoring equipments for valve operation and data acquisition in order to indicate the moment when a test valve is no longer operate in normal parameters, with of course questioned the technical functioning of the whole system and consequently of the engine itself.

The equipments used for monitoring and data acquisition were chosen in order to be able to display and store both the number of on/off switching events that occurred at that valve until the fail occur and values from pressure and temperature sensors of the test bench developped.

Processing of experimental data acquired and stored, their interpretation and presentation of conclusions will be made using dedicated software. Using data from measurements on the test bench will be able to predict when such failures occur, establishing such a predictive criteria of failure, which possibly could be integrated in near future into onboard diagnostic systems used nowadays in automotive domain.

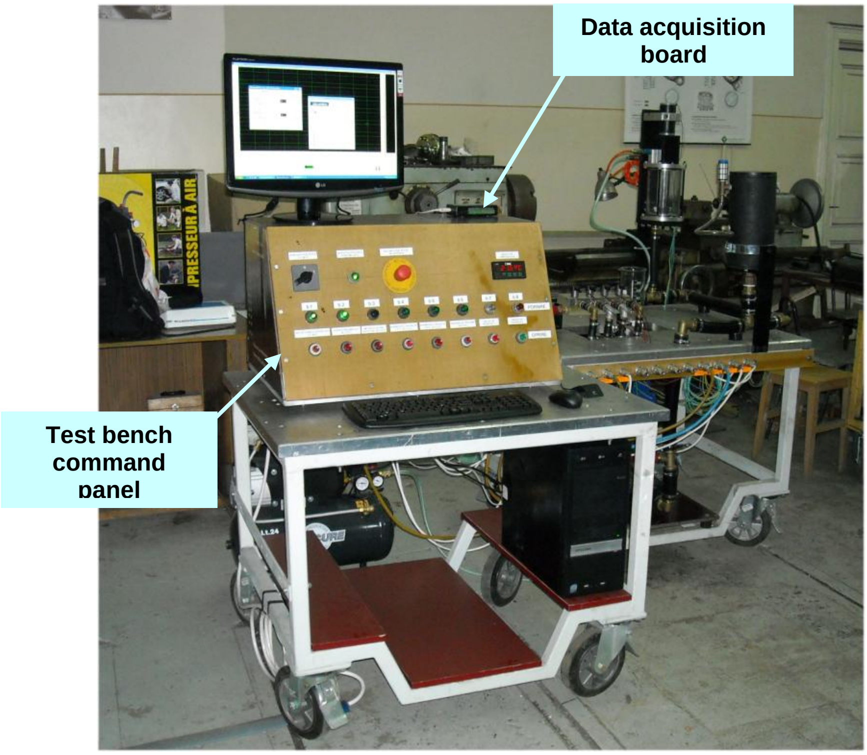

Fig. 1 Overview of the test bench developped for electrohydraulic valve test

For the tests and their results obtained an acquisition system, control, visualization and storage of experimental data was used (figure 2), consisting of:

- Pressure sensors, Wika EcoTronic type;
- Temperature sensor, PT100 type;
- Amplifying and display signal from the temperature sensor device, type AMR MT 4481-2;
- Data acquisition board, type Advantech USB 4761;
- Integrated control board for tested valves.

The pressure sensors are EcoTronic type, being a product of the company Wiega (figure 3). They pressure measurement range is between 0-10 bar. The measured pressure is converted into electrical signal in the form of voltage (0-10V). It is calibrated so that its value at 0 V is equivalent with the value of 0 bar pressure and the value of 10 V is equivalent for the 10 bar pressure. So, sensor measuring range is between 0 ... 10 bar. Supply voltage range for this type of sensors is between 14 and 30 V. Both housing and sensor components which come in contact with the transmission fluid pressure are made of stainless steel. Pressure transmission fluid used is a synthetic oil. For information on its apparent accuracy, the pressure measurement error may be ≤ 0.05 bar to 10 bar pressure value measured, which means a measurement error ≤ 0.005 bar at a value of 1 bar pressure measured.

The temperature sensor used for the test bench is a PT100/A/4 temperature type sensor based on platinum (figure 3) and it is used to measure oil temperature. This is actually a temperature dependent resistor.

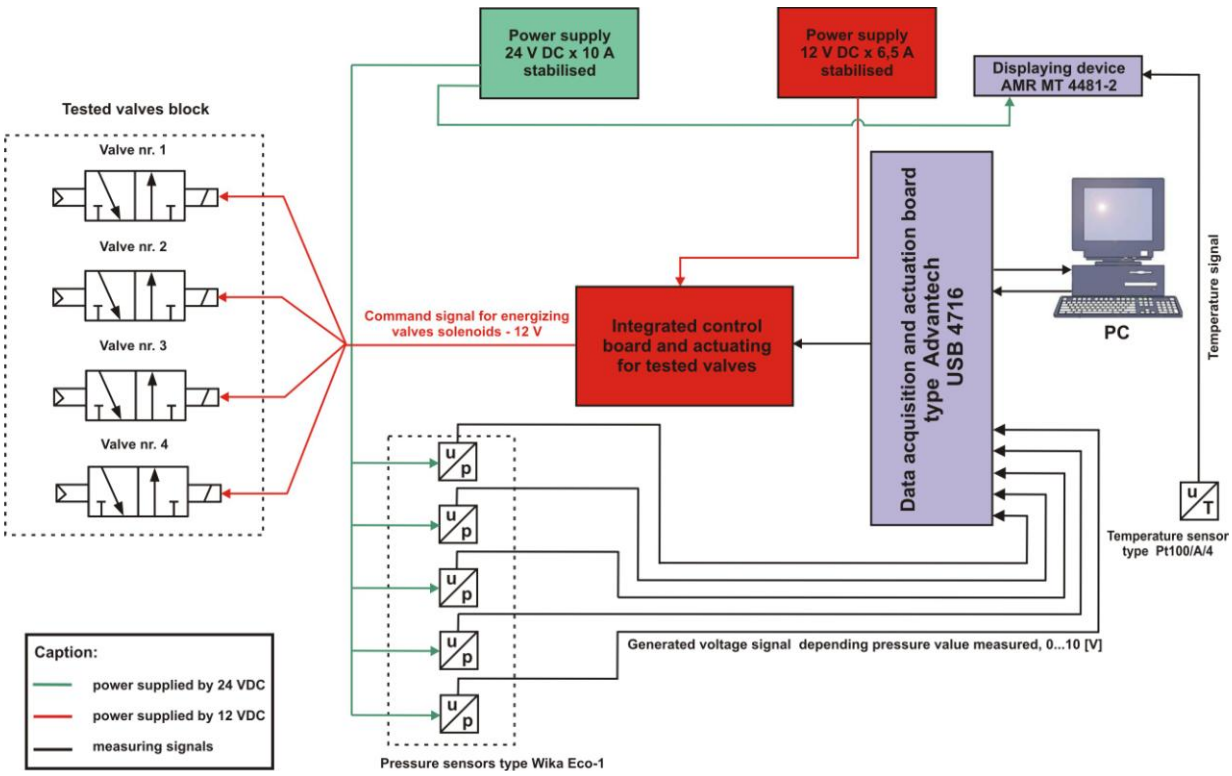

Fig. 2 Block diagram of the measuring system of the test bench

Fig. 3 Pressure and temperature sensos used for the test bench

Amplifying and display signal from the temperature sensor device is typically AMR MT 4481-2 and was acquired by the company Ahlborn Mess-und Regelungstechnik (figure 4). This device allows the connection of temperature sensors that operate based on resistors and other sensors that give the output signals as current or voltage.

Fig. 4 AMR MT 4491-2 device used for the test bench

Data acquisition board used is an external USB type 4716 produced by Advantech company (figure 5), its power supplying and data transfer to your PC is being done through the USB port. Board control software is installed on your PC hard drive test stand. This board is part of the USB 4700 acquisition solutions manufactured by Advantech, which is a Plug & Play device. It is efficient and easy to install, no need for a separate PCI port of computer is required.

This acquisition board supports USB 2.0 standard and is portable. It has a total of 16 analog input channels with 16 bit resolution with a sampling rate of up to 200 kS/s. Field voltage of the analog inputs can be bipolar (± 10, 5, 2.5, 1.25, 0.625 V) or unipolar (0 ~ 10 V, 0 ~ 5V, 0 to 2.5 V, 0-1, 25 V).The board also has 8 inputs and 8 digital outputs, two analog outputs and a 32-bit counter.

Fig. 5 Data acquisition board used for the test bench

When launching the application that comes with purchasing card drivers Advantech Device Manager window appears (figure 6). In selecting the analog input configuration menu, appears in the left display the number of analog input channels which could be set for each field input voltage (e.g. 0-10V). User can switch between the 16 input channels by pressing buttons "arrow" on the right of the screen. Also you can select the right sampling period (e.g. 1000 ms).

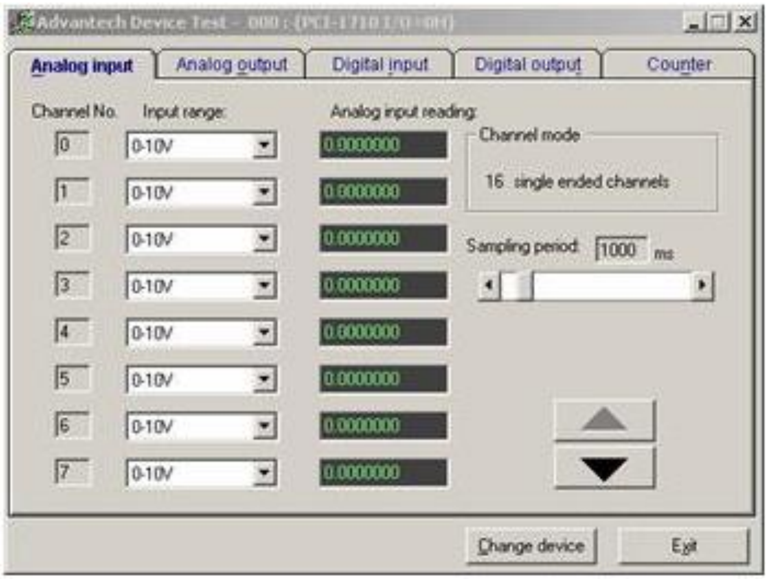

Fig. 6 Analog input window from Advantech Device Manager

When selecting analog output configuration menu (figure 7), appears in the left side of the window, the number of analog output channels. For each channel can be configured the output signal form (sinus, teeth, gear), its minimum and maximum values, or may be given a single constant value output signal. It can switch between the two output channels by pressing buttons "arrow" on the right of the screen. All the right you can select the duration of the signal.

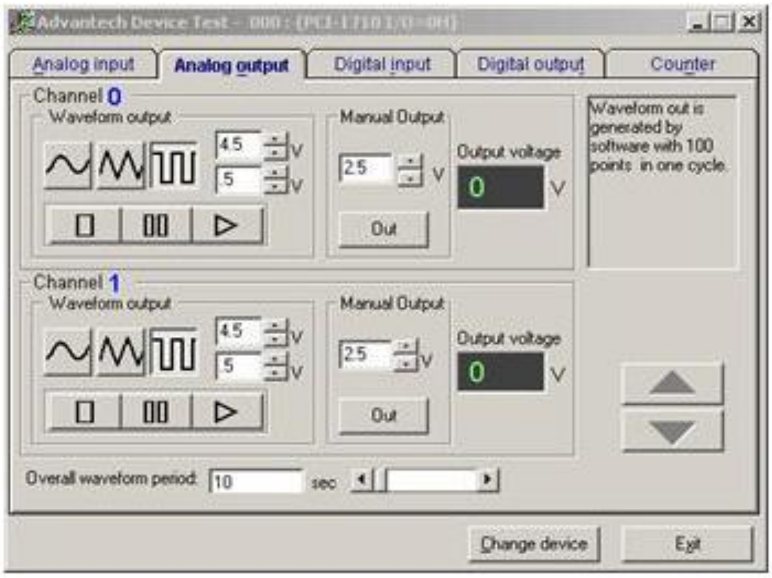

Fig. 7 Analog output window from Advantech Device Manager

Besides Advantech Device Manager application, was also used Wavescan 2.0 software (figure 8).

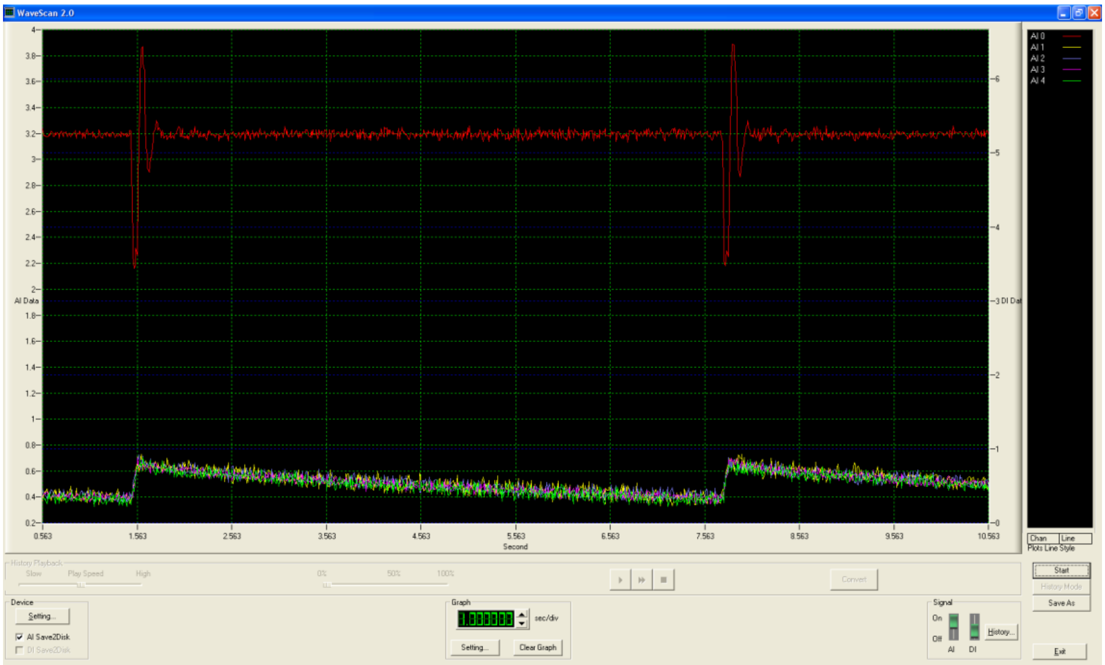

Fig. 8 Displaying input signals in Wavescan software window

Wavescan 2.0 software can be viewed by user the real-time values from pressure sensors that collect data from a total of 16 simultaneous acquisition channels. In the configuration window of the program (figure 9) is selected purchase board type, number of channels that the boards were made, sampling rate, length of display data. The program allows you to save data (figure 10), accomplishing a historic values library and export them in a format recognized by Microsoft Excel. It is also possible to view historical data and graphs for any time previously saved them.

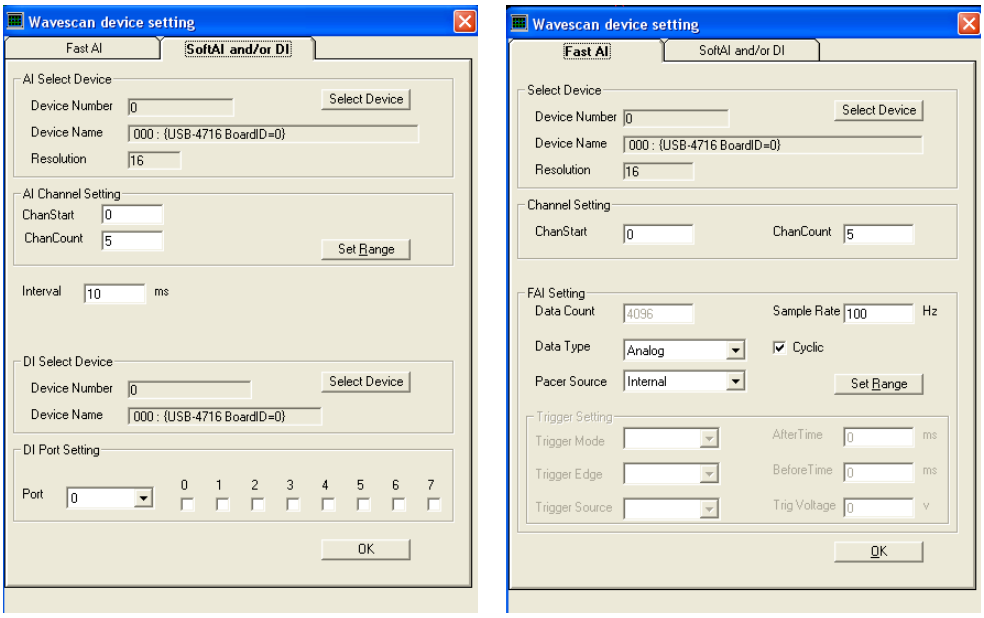

Fig. 9 Wavescan 2.0 configuration window

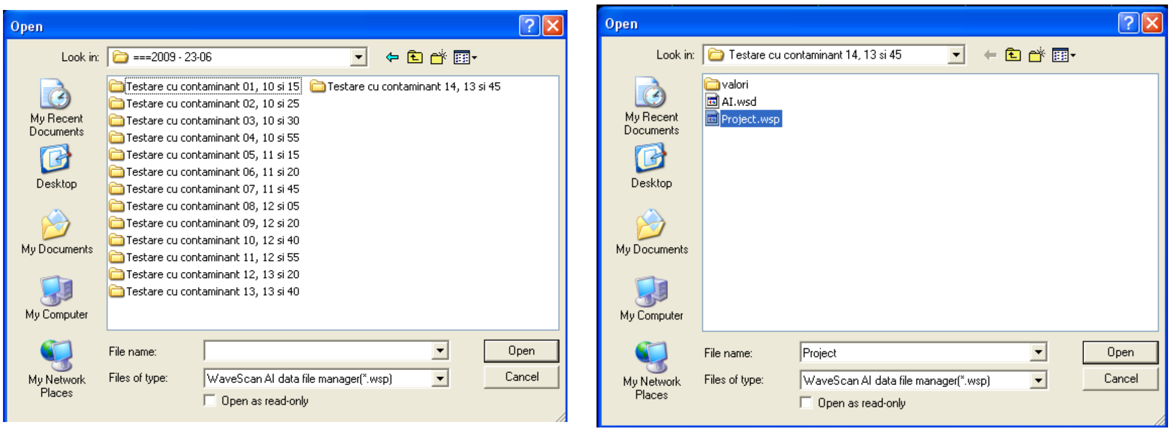

Fig. 10 Wavescan 2.0 data storage window

Integrated control board for tested valves together with data acquisition board has the role of command the valve opening from the test block. In acquisition board software could be set the opening period (T) for the tested valves. This signal leaves the acquisition board being a step voltage input type with values from 0 ... 5 V (figure 11, blue graph) and this is input signal in integrated control board for tested valves. Here, the signal is changed, the output of integrated motherboard achieving a step voltage input type, with values between 0 ... 12 V (figure 11, red graph), with a period (T) about 6 seconds, and the duration control pulse is 0.2 seconds. The latter is the opening signal applied to the tested valves.

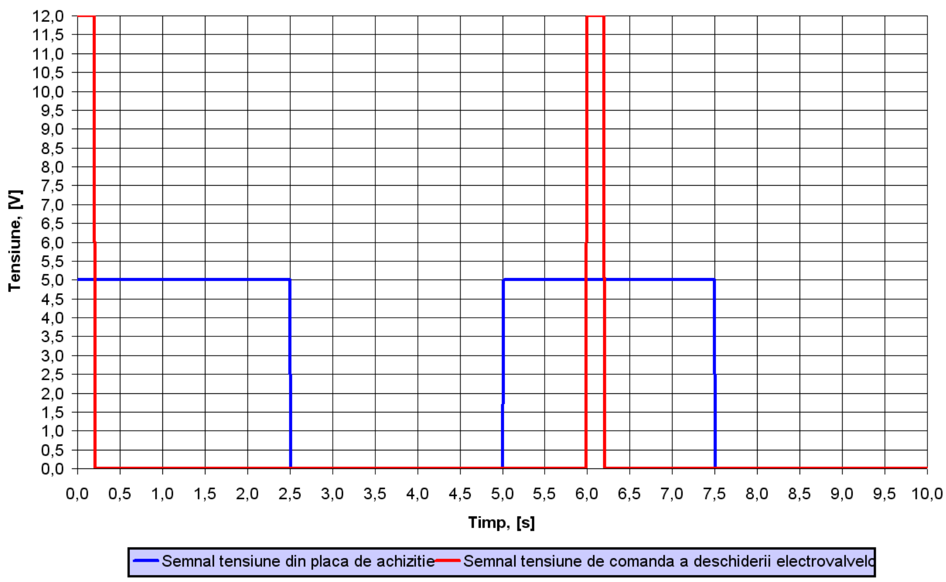

Fig. 11 Output DAQ signal vs. opening signal for the tested valves

Opening voltage signal for the tested valves is sent to them via a PC and a integrated control board (figure 12), performed in the department of motor vehicles and engines of the faculty of Mechanical Engineering at Transilvania University of Braşov.

Power floor of the integrated board consists of a Darlington type amplifier. Final transistor T2 is protected from inductive loads (arising from the phenomenon of self-inductance) by locating the load diode reverse D. The board is also supplied with voltage of 12 VDC.

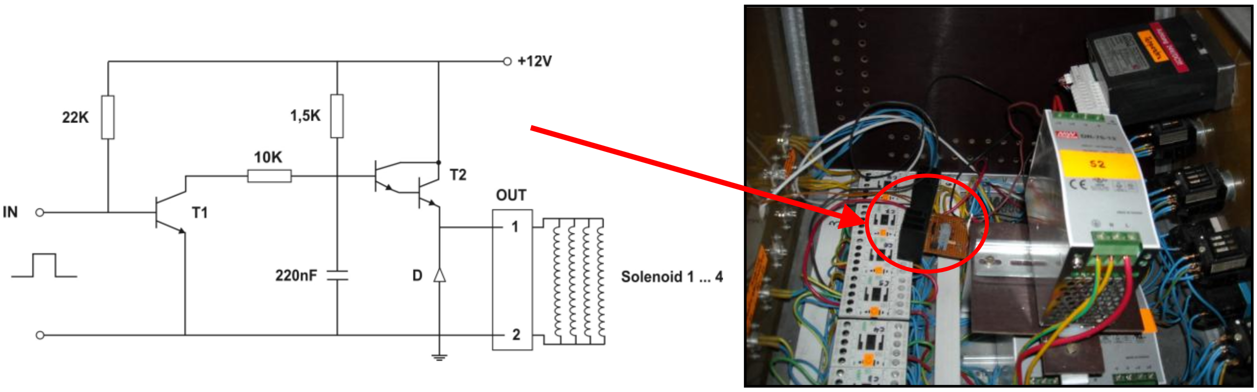

Fig. 12 Integrated control board developped at the university

CONCLUSIONS

The monitoring equipments integrated on the test bench for valve operation and data acquisition are able to indicate the moment when a test valve is no longer operate in normal parameters.

The equipments used for monitoring and data acquisition is able to display and store both the number of on/off switching events that occurred at that valve until the fail occur and values from pressure and temperature sensors of the test bench developped.

Processing of experimental data acquired and stored, their interpretation and presentation of conclusions was made using dedicated software. Using data gained from measurements will in future be able to establish a predictive criteria of failure, which possibly could be integrated into onboard diagnostic systems used nowadays in automotive domain.

BIBLIOGRAPHY

[1] Brüstle, C., Schwarzenthal, D. - *The „Two in One“ Engine – Porsche's Variable Valve System*. SAE Detroit, 1998.

[2] Golovatai-Schmidt E., Schwarzenthal D., Geiger U., Haas M., Scheidt M., *Technologies for variable valve trains; A contribution to modern S.I. engines*. The 10th International Congress CONAT, Braș ov, 2004.

[3] Golovatai-Schmidt, E. - *IMH Ventileigenfertigung - Einfluss der Primär- und Sekundärverschmutzung auf die Ausfallwahrscheinlichkeit von Elektroventilen*, IMH-LVE, Schaeffler KG, Herzogenaurach, Germania, 2001.

[4] Hagemeister, W., Matuschka, J. - *Endurance test bench for hydraulic valves under extreme ambiant conditions*, 5th International Fluid Power Conference Aachen, 2006.

[5] Linsmeier, K., Greis A. - *Electromagnetic Actuators. Physical principles, types of design, applications, Verlag Moderne Industrie*, Second Revised Edition, 2000.

[6] Săraru, S., F., - *Cercetarea electrovalvelor distribuției variabile a motoarelor în vederea diagnosticării la bord.* Teză de doctorat. Universitatea Transilvania din Braș ov, 2009.

[7] Schwarzenthal, D., Hofstetter, M., Deeg, H-P., Kerkau, M., Lanz, H-W. - *Die VarioCam Plus, innovative Ventilsteuerung des 911 Turbo 9.* Aachener Kolloquium Fahrzeug- und Motorentechnik 2000 Aachen, 2000.

[8] *** - *Testing valvetrain systems for combustion engines*. Publication VVV, INA-Schaeffler KG, 2003.