DESIGNING AND MANUFACTURING A TEST BENCH FOR TESTING ENGINE VARIABLE VALVE TIMING SYSTEM ELECTROVALVES

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KEYWORDS – Test Bench, Electrovalves, Variable Valve Timing, Contamination Behaviour, Vario Cam Plus

ABSTRACT – The article refers to designing and manufacturing of a test bench used for studying contaminantion behaviour of some components of the vehicle engine variable valve timing system.

Particulary, the test bench was created in order to be used for research electrohydraulic valves sensitivity. These type of valves are part of the variable valve timing mechanisms, like Vario Cam Plus. These systems have a large applicability on the internal combustion engines used nowadays, due to their advantages like: fuel consumption reduction, polluant emission decrease, and engine performance improvement.

Ingressing the particles from the contaminated oil of the engine between the component parts of the electrovalve, cause malfunction in operation, extended afterwards on the variable valve timing system and finally on the operation mode of the engine itself. Consequently, fuel consumption increase, polluant emissions also, and engine performance decrease.

In conclusion, the necessity of designing and manufacturing a test bench in order to reproduce the operating conditions from the engine equipped with these type of variable valve timing systems, came naturally.

MAIN SECTION - variable valve timing mechanisms, like Vario Cam Plus have a large applicability on the internal combustion engines used nowadays, due to their advantages like: fuel consumption reduction, polluant emission decrease, and engine performance improvement. In case of these type of engines, at the moment the oil flows through the electrohydraulic valves, these components direct it to engine devices responsible with the engine valve timing variation. 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.

Thus, once affected the proper functioning of the valve, the immediate consequence arising from it is given by the major implications on the functioning of the variable valve timing system, of which it forms part and implicitly of the engine behavior in operation.

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 at the Transilvania University under the guidance of Schaeffler KG, Germany. This is imperative to be conducted to identify factors that may cause problems in valve

operation and subsequently determining the minimum period of operation without failure. Once identified these factors, in the near future could be found new constructive solutions with the main task in reducing, or if is of course possible, even eliminate the influence they generate.
In figure 1 a schematic diagram of hydraulic circuit of the test bench is shown. After this was sketched, it became the start point for the CAD virtual model of the test bench developped using the Pro Engineer Wildfire 2.0 software. After validating the CAD model, the real test bench designed for experimental research was constructed in the university laboratory.

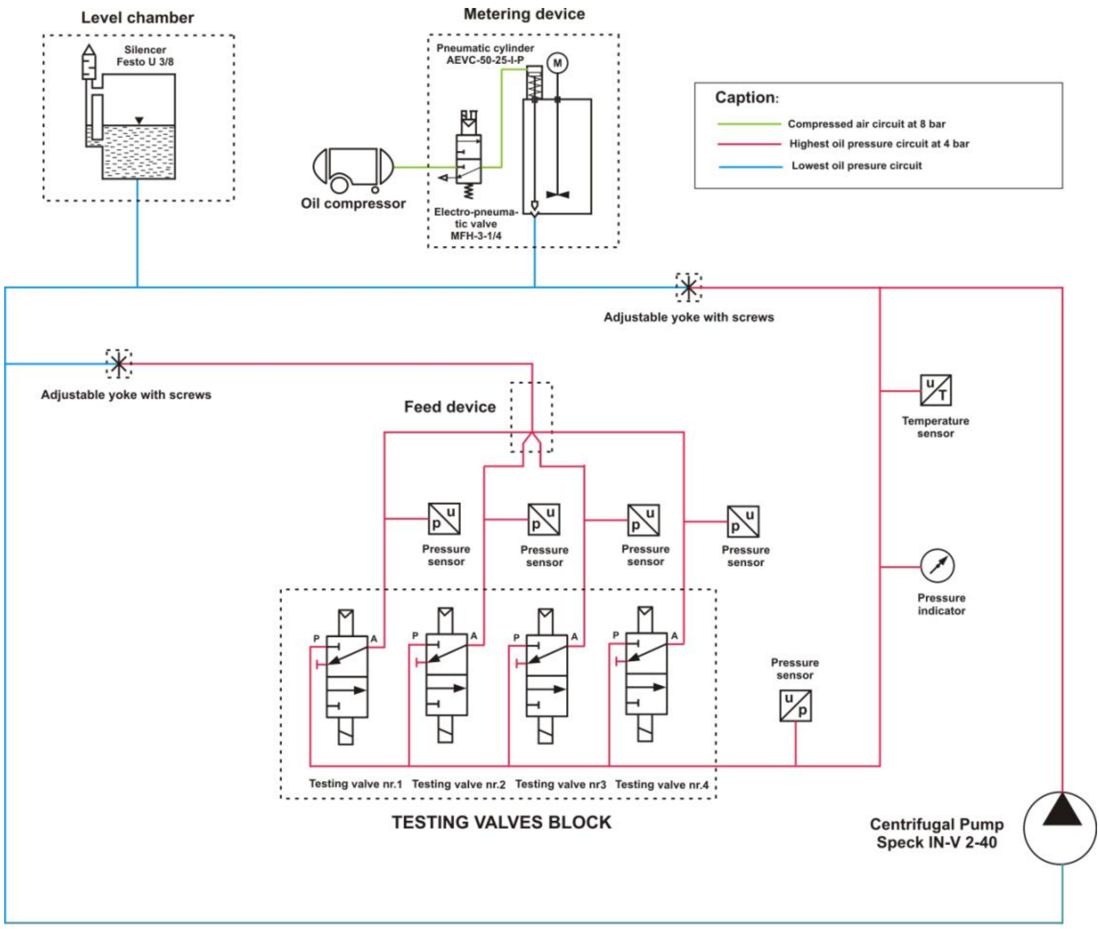

Fig. 1 A schematic diagram of hydraulic circuit of the test bench developped

As can be seen from the figure above, different components of the test bench can be observed. Oil, together with contaminating particles are introduced through the metering device, comprising a hermetic chamber on the inside, with a mechanical stirrer driven by an electric motor, serving to maintain the particles introduced inside, in constant motion.

Further oil and impurities flowing on the hydraulic circuit, is made by moving a rod, that by raising the head of his hole, opens a communication orrifice with the entire hydraulic circuit of the test bench. The rod moving is made by a 6 bar air pressure, given by an oil compressor and directed by a pneumatic valve, 3/2 type, controlled by an electromagnet to a simple-acting pneumatic cylinder with spring.

At values of 6 bar pressure obtained at the entrance of the pneumatic cylinder, the rod closes the communication orrifice with the rest of the hydraulic circuit. By changing the direction of

flowing for the compressed air through pneumatic control valve, the air pressure is gradually released silently into the air, using a pneumatic silencer. Once air pressure from entering the cylinder rod is released, its spring force rises the rod from its hole opening the communication of the metering device with the rest of the circuit.
Working pressure of oil in high pressure hydraulic circuit (4 bar) is performed using a centrifugal pump and adjusted with two adjustable yokes with screws. Using this solution prevents the occurrence of sudden break-section and of some areas where contaminant deposits might appear. Centrifugal pump has the advantage that it does not crush the contaminant particles, and because they provide high flow, it keeps them in constant motion.

There is also a low pressure part of the circuit, marked with blue, which has a a level chamber device, which is used for maintaining the hydraulic pressure balance and damping oscillations and hydraulic shocks of the circuit. The level chamber is without separation of the two air/oil environments.

The Oil with high-pressure is directed to the tested valve block. On this, as can be seen in figure nr.1 four valves are located in order to be tested. Oil pressure values at the entrance of the valve block, and at the exit from each of the four valves is monitored using five piezoelectric pressure sensors. The value of the oil temperature is monitored using a temperatura sensor with, type PT100. After leaving the tested valves, oil is directed before the centrifugal pump by a feed device with four inputs and one output. The oil is consequently directed to the section of the suction centrifugal pump, where pressure is used to get about 4 bars, after which the oil will be eventually reintroduced back into the block. To view the oil pressure value just before entering the block, was used a pressure indicator (a manometer).

Starting from the test bench hydraulic scheme described before, a three-dimensional model of the assembly of the test bench was developed using the CAD program, Pro Engineer Wildfire 2.0. The subassemblies with all component parts of the test bench, were modeled using Pro, whether they were designed and then put into production, or were just purchased from different providers. Having modeled all these components we were further able to make several versions of their location on the test bench, and finally after made some analysis, choosing the optimal variant, shown in figure 2.

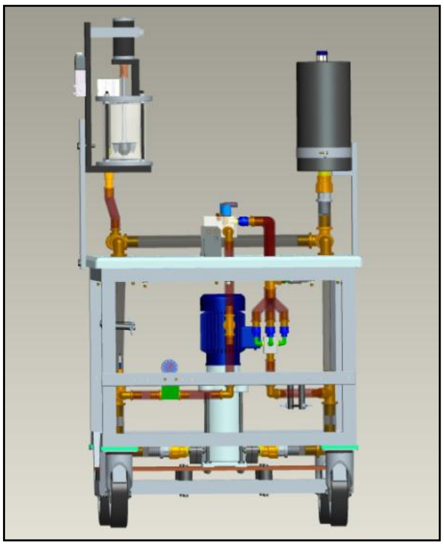

Fig. 2 The CAD Model of the test-bench

After validation of the optimal variant of the CAD model of the test bench and after having all necessary parts we were then alble to pass to the assembly stage and accomplishing the real test bench in laboratory.

In figure nr. 3-5 some overviews of the test bench developed at the university are presented. Are also highlighted the two main modules of the test bench, as it follows:

• the hydraulic and pneumatic module – on the right side, in the plane near;
• electric, electronic control and data acquisition module - on the left side, in the plane away.

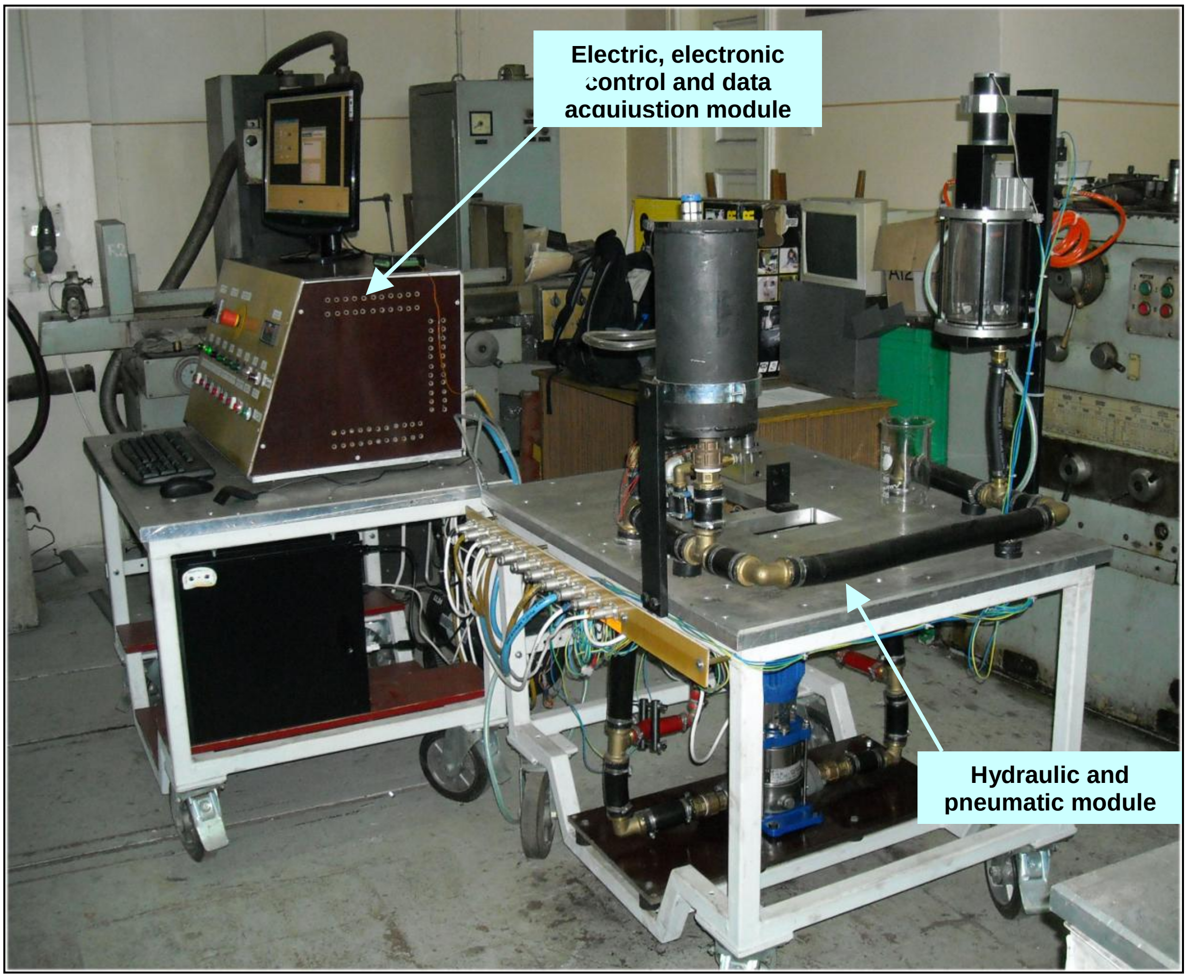

Fig. 3 Overview of the test bench for electrohydraulic valve test

In figure nr. 6 is presented electrohydraulic valve block mounted on the test bench. This block was made of plexiglass. This material has a high degree of transparency (nearly 90%) is thus possible for didactical scope, viewing oil flow inside its channels and before entering, or leaving the valves tested.

It was chosen this type of material because this can be processed relatively easily, has good strength, not a high cost price and are manufactured in rectangular blocks close to the desired size.

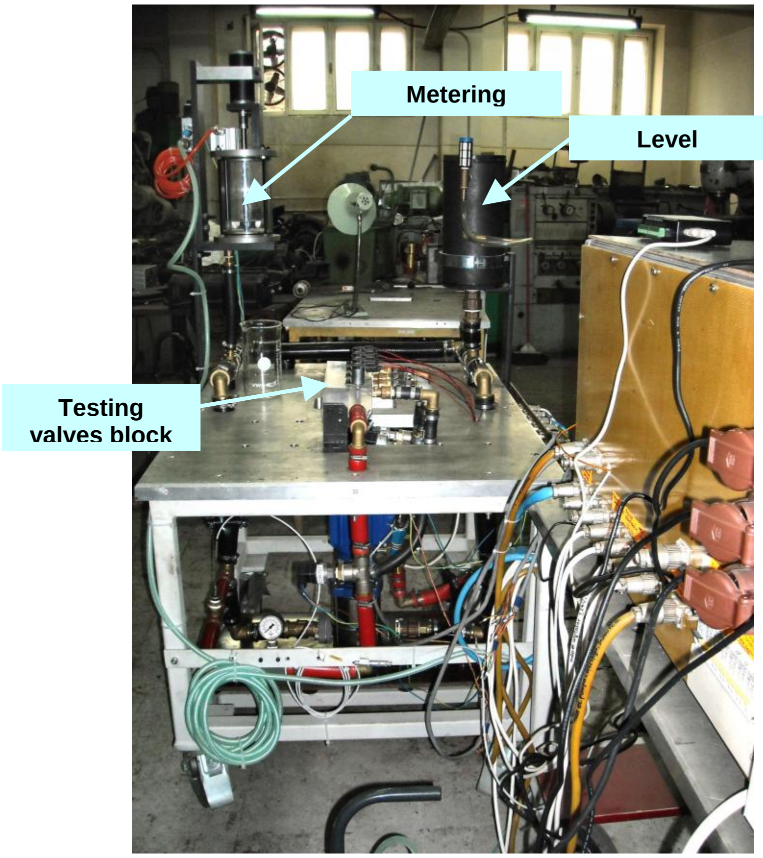

Fig. 4 Overview of the test bench for electrohydraulic valve test

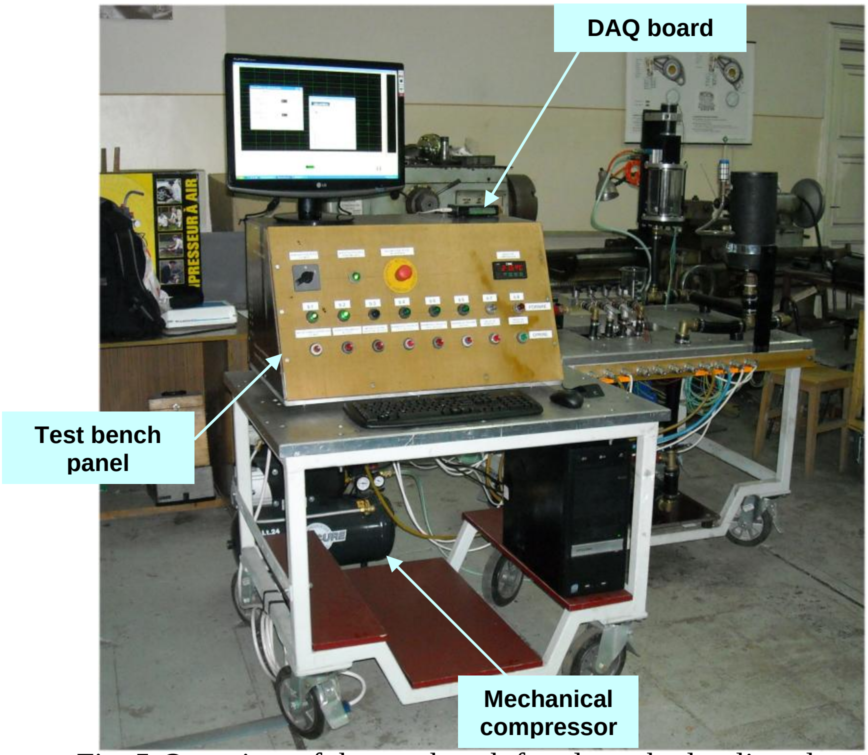

Fig. 5 Overview of the test bench for electrohydraulic valve test

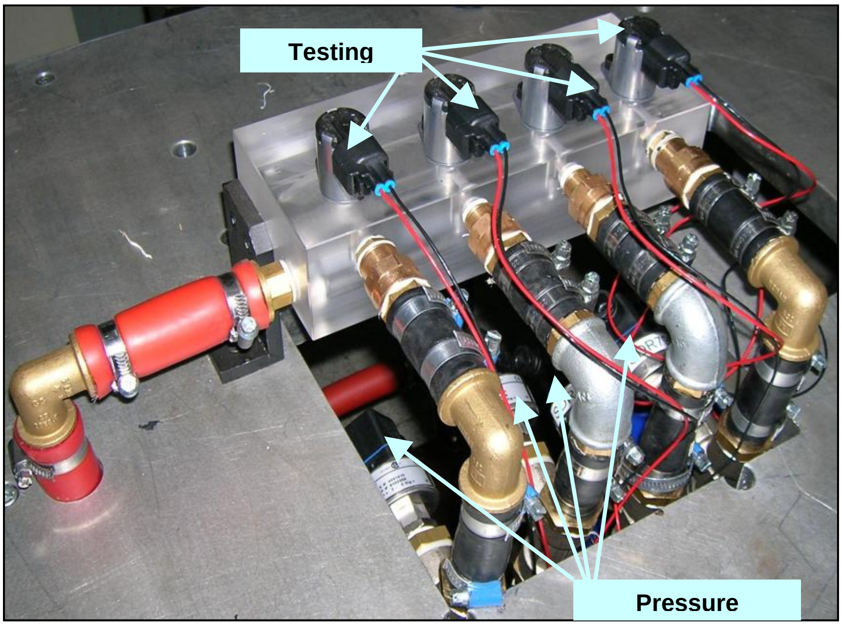

Fig. 6 The testing electrohydraulic valves block

CONCLUSIONS

Designing and developping the test bench presented, means better monitoring of the electrohydraulic valves, part of the variable valve timing system. This is imperative to be conducted in order to identify factors that may cause problems in valve operation and subsequently determining the minimum period of operation without failure. Once identified these factors, in the near future could maybe be found new constructive solutions with the main task in reducing, or if is of course possible, even eliminate the influence they generate.

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.