Computer Automatic Control for the Engine Test Bench Schenck W-150

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***Abstract* – In this paper, one method for automatisation of the engine test bench and the application for computer controlled execution of test for deposit estimation in the inlet system of petrol engines is shown. It is presented how the test procedure is executed automaticaly by PC with built-in card for control and data acquisition, and also using an appropriate user defined software solution.**

***Keywords* – Automatic control, Data acquisition, Test bench**

I. INTRODUCTION

One big laboratory for engine testing is placed in the Institute for Automobiles – Zastava Car factory, Kragujevac, Serbia. Among the hydraulic test benches, there are also two electrical motor test bench produced by Schenck type W-150, and one motor-generator test bench produced by Siemens, purchased about 40 years ago. These test benches are in very good conditions regarding to mechanic parts and also electronic, analogue computer, because of good maintenance and appropriate handling.

This test bench, Schenck W-150, has a predisposition for automatic control, then, an analysis was done and a proposal to upgrade this for automatic laboratory testing was given.

Methodology for computer data acquisition and automatic control was developed. All necessary parameters for control and observation during the testing were defined. Then, the equipment which has to be built in the laboratory and the other one which can be used on the other places was specified.

II. TEST BENCH AUTOMATIZATION

Engine test bench "Schenck W-150" is with an appropriate electronic system which gives opportunity to control the load by external voltage. So, it was enough to make a new contact for voltage supply from D/A converter in the PC.

Throttle valve control was by hand. To do testing procedure automatically, it was necessary to introduce automatic control. One very simple solution was chosen. Step motor and rotational potentiometer as a throttle position sensor were purchased. Then, control software driver was written. Throttle valve control and throttle position measurements can be done by LPT i.e. PC parallel port [1], or by digital I/O from data acquisition and control PC card [2].

Engine test bench already had a taho generator connected with an analogue indicative instrument. Signal from taho generator is leading to the connecting panel of the acquisition card.

Also, test bench has an already assembled force transducer by "HBM", which is very reliable and high quality, and an appropriate analogue amplifier with digital display. It was necessary, only, to derive analogue voltage signal to the data acquisition card.

To measure fuel consumption, it was necessary to upgrade fuel tank with flush fuel pump and with installation for recirculation. For this purpose, volumetric gauge by "Pierburg" are used, because they do not affect on the fuel pressure in the delivery line.

Air consumption measurement is done using mass flow gauge by hot wire, "Degussa" or air mass flow sensor "Bosch" assembled in serial car production. Both sensors have analogue voltage outputs which are suitable for connecting with data acquisition card.

Ambient conditions, i.e. interior temperature and absolute atmosphere pressure, are measured by one integrated sensor which is in serial car production [3].

To measure engine oil temperature, temperatures of the inlet and outlet water for engine cooling, air temperature in the intake system, etc., type of semi-conductor sensors LM334 and LM335 are used. These sensors give absolute temperature in the range of 0÷100°C. Both of them are suitable for connection with data acquisition PC card, and they are very cheap. It is only necessary to make good, protective, metal cases for these sensors.

Exaust gas temperature is very high, and this can be measured only by thermocouple sensors type NiCrNi or PtRhPt. Signal from these sensors should be amplified before data acquisition card.

Content of exaust gas is measured by portable gas analysers "Pierburg" and "Beckman". From both of them it is possible to connect voltage outputs with data acquisition card.

Stechiometric mixture content, i.e. "Lambda factor", is measured by specific device "Lambda meter" whith an analogue voltage output, proper for connection with data acquisition card.

For data acquisition, i.e. data collecting in the PC and test bench control, PC card "ED2000" [4], is used, because this card can solve all problems, and we have a great experiance using it during a couple of years, and big library for various applications which are already done.

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III. TESTING GASOLINE ADDITIVES

For improving the quality of gasoline produced for public distribution, i.e. for improving all characteristics of OTO engines (torque, power, speed, fuel consumption, exaust gas emission, etc.), petrol producers in cooperation with car producers, intensively are working and developing new methods and procedures for qualification of petrol quality.

Based on the existing method by Coordination European Council (CEC F–04–A–87), NIS (Serbian Petrol Industry) gave approval to Zastava Car factory to develop test method for qualification of gasoline with new additives quality [5]. This test method rates the quality of gasoline with new additives regarding to the deposits which this fuel apply onto the intake system elements (i.e. carburettor, inlet manifold, inlet tunnels, inlet valves and combustion chamber), for the period of 40 hours, see Table 1.

For execution "CEC test", i.e. for testing gasoline with different additives, test bench was modified and upgraded. Because of specific test conditions, a simple device for intake air heating to the temperature of 88 ± 2 ^{o}C is designed and realized. This device is consisted of one tank with inlet and outlet air channel. Outlet air is distributed to the engine intake manifold and air filter inlet. Tank has 5 electric heaters, each power of 1.1 *kW* which are in switching ON/OFF mode, and one heater, with same power, has regulation by thyristor. Block scheme of the complete system is shown in Fig 1.

Before the test starts, it is necessary to take engine warn-up stage, until the working conditions, and if entirely new engine, for the first time, is on the test bench, then it is necessary to take running-in stage for new engine. "CEC test" itself, is executing on the test bench with stimulated testing conditions, i.e. engine should suck hot air, which is heated to the temperature of the 88 ^{o}C.

TABLE I
STAGES FOR CEC TEST

Stage	Duration (min)	Engine Speed (rev./min)	Moment (Nm)	Intake Air Temperat. (^{o}C)
1	0.5	1200 ± 50	2.0 max	88 ± 2
2	1.0	3000 ± 50	35.3 ± 2	88 ± 2
3	1.0	1300 ± 50	29.6 ± 2	88 ± 2
4	2.0	1850 ± 50	32.5 ± 2	88 ± 2

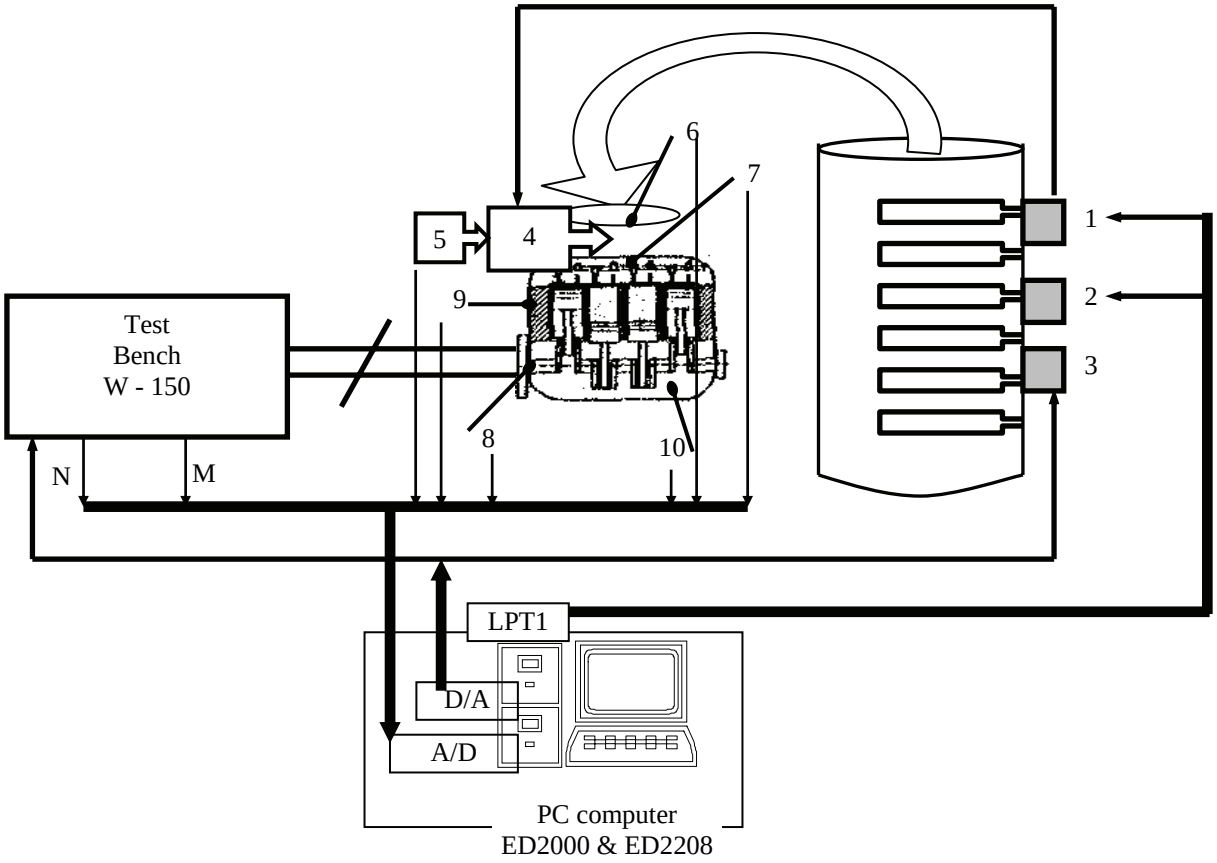

Fig. 1. Block scheme of automatized test bench W-150 ready for execution "CEC test":
1. Step motor driver; 2. Electric relay for heaters; 3. Regulation by Thyristor; 4. Step motor with reductuon gear; 5. Rotational potenciometar; 6. Intake air temperature sensor; 7. Intake air pressure sensor; 8. Engine cooling water inlet temperature sensor; 9. Engine cooling water outlet temperature sensor; 10. Engine oil temperature sensor.

IV. APPLICATION SOFTWARE

PC cards for data acquisition and control ED2000 are using by engineers at Zastava automobiles for a long period. For comfortable working and implementation these cards, a drivers library were writen in Turbo Pascal, firstly, and then also in Delphi programming language.

Test execution is completely automated. Appropriate application software, writen in Delphi programming language, using PC parallel port and A/D, D/A cards for data acquisition and control, ED2000 and ED2208, respectively, and actuators, is controlling test bench working and throttle opening. By controlling the throttle at engine carburettor, the change of engine mode in desired moment can be done automaticaly.

All measured data are aquired and saved in data file with one second sampling time.

Simultaneously with engine mode changing and holding, application software takes care about intake air temperature retaining. Heaters relay are switched on/off by parallel port LPT1, and one output of the D/A card ED2208 is used to control thyristor regulator, for fine regulation of the power of one heater. The response of the intake air temperature changing is very slow regarding to the moment of heater switching on. Because of that, it is very difficult to make very good and successful regulation if disturbances are very frequent and impulsive.

The fact is that stages for CEC test are known in advance, and that unexpected disturbances are very rare. This simplifies control algorithm for air temperature. Regulation is done in the closed loop, but there is a state prediction which makes minimal variations of the temperatures in the transient modes.

The application for users and CEC test operators is shown in Fig 2. This application is used for control and data acquisition. When application software is started, after iPC cards initiations, step motor firstly is closing the throttle. This is done with predefined and sufficient number of steps so the throttle is reliable closed. After that, the throttle is opened to maximal position. By this way, the exact throttle position can be determinated later.

Hereafter, the application is positioned in the stage "ručni rad", i.e. "manual operation". In this stage two scroll bars are opened (below the heaters status in Fig 2.). One scroll bar is for setting the reference engine speed (i.e. the load for test bench) and the other one is for setting opening of throttle. In this way, the basic function of the test bench is retained, and it is possible to start the engine for the first time. Also, in this mode it is possible to switch on/off five heaters by pressing the buttons "Povecaj" and "Smanji", i.e. "Increase" and "Decrease", respectively.

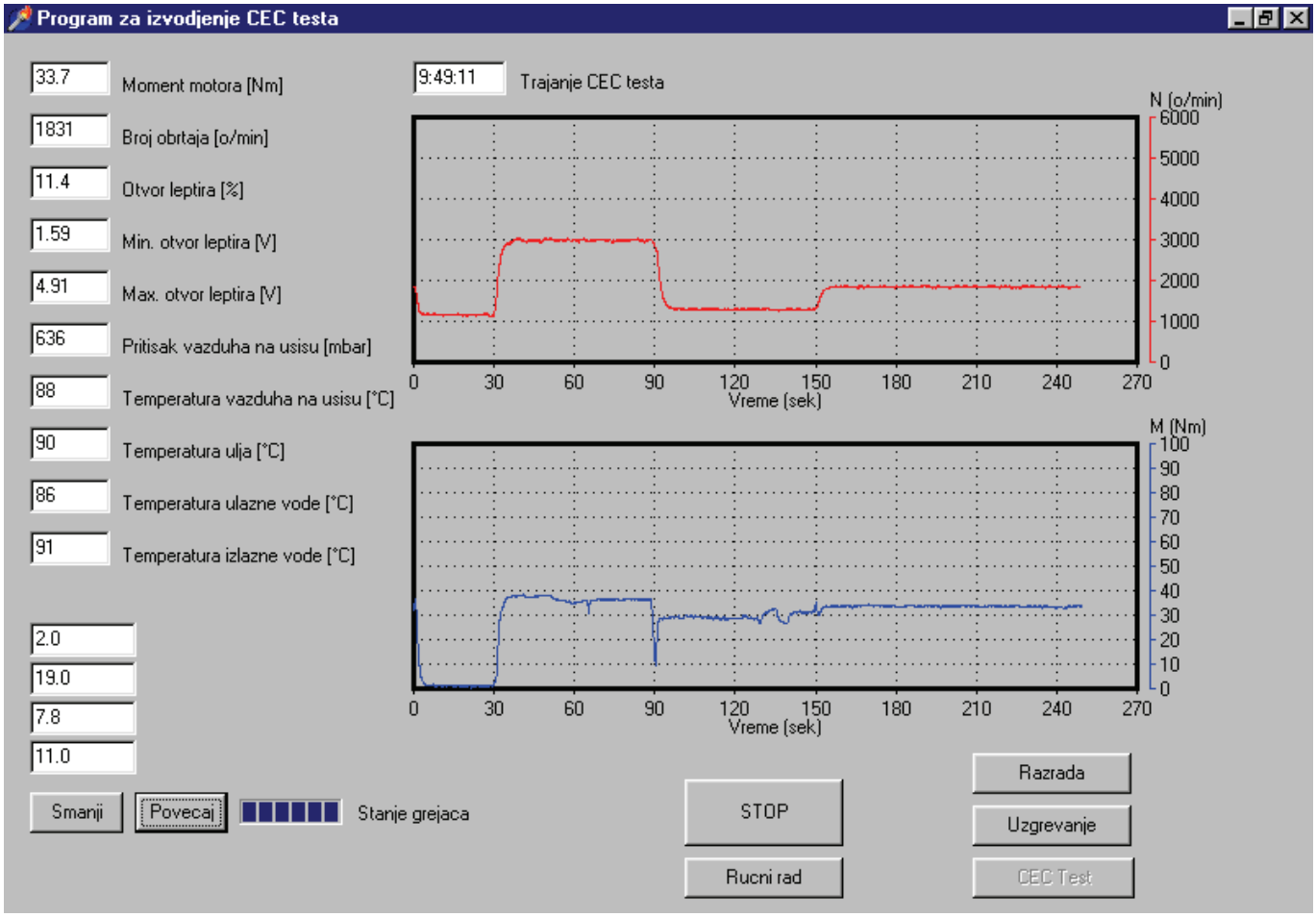

Fig. 2. Application for CEC test execution at the engine test bench

After the automatic mode starting, (stages "Uzgrevanje" i.e. warm-up, "Razrada" i.e. run-in or "CECTest", the possibility for setting up engine speed or throttle opening are not allowed. Also, buttons to heater switch on/off have no function, but they are showing the status for active heaters.

When new engine is mounted for the first time at the test bench, automatic work is runing in the mode "Razrada", i.e. run-in. Operating conditions are specially defined.

Mode "Uzgrevanje" i.e. warm-up, is also specially defined, and it is used always before the CEC test. When operating engine conditions are fulfilled, the application automatically is turning off test engine because of necessity to measure the weight of engine oil. After that, by established methodology, the test engine is starting again and the mode "CEC Test" for automatic operation is activated.

PC card ED2000 can contain eight differential analogue inputs, then this number of most important inputs are taken for data acquisition in the data file and are shown on the display. Also, these data are serving for test condition checking.

As an illustration of working in laboratory for engine testing, the photo of test engine, produced by DMB Serbia, 1301ccm, assembled carburettor with two throats, and some parts of the equipement is shown in Fig. 3.

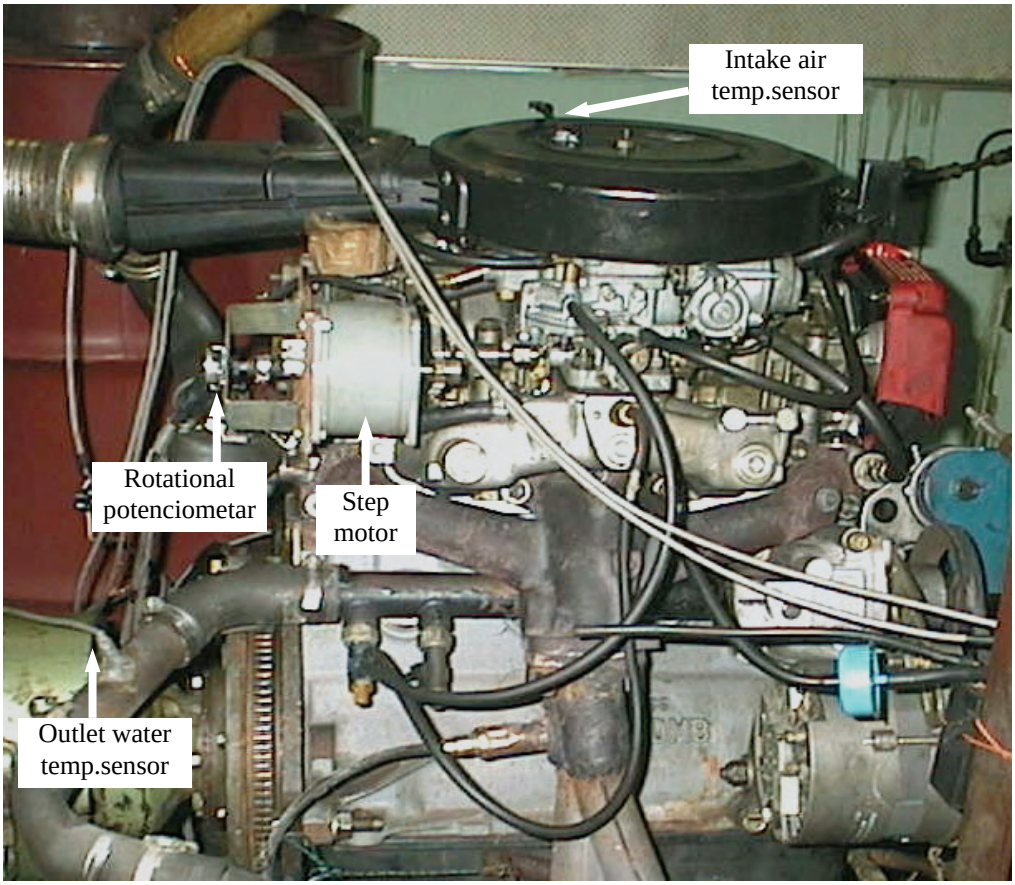

Fig. 3. Test engine photo

V. Conclusion

This example shows how it is possible to completely automate worth and specific lab equipement, with very low investment. Hereafter, it is possible to use this equipement for various experiments and tests, only making an adequate software. This software is user friendly, and training for operators is very short and simple.

Because of its capabilities, test method shown in this paper, can be used not only for qualification of gasoline with different additives, but also for testing and qualification all engine fluids. For example, different engine oils can be tested using the same fuel. Qualification can be done in the same way as for fuels, by measuring and comparing accumulated deposits into the intake system.

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