

AUTOTRONICS COURSE – AN INOVATIVE APPROACH IN AUTOMOTIVE МЕХАТРОНИКА ОБРАЗОВАНИЕ

КУРС AUTOTRONICS – ИНОВАЦИОННЫЙ МЕТОД ОБУЧЕНИЯ В ОБЛАСТИ АВТОМОБИЛЬНОЙ МЕХАТРОНИКИ

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Abstract: The paper describes an Autotronics course addressing the current and anticipated skill shortages of car mechanics and employers in car garages. The course uses an innovative, blended learning approach, which combines multimedia and Internet-based e-learning with sophisticated classroom training in order to prepare the European roll out of the service with special reference to local market requirements and demands. The course contains a comprehensive suite of three e-learning modules, which allow self-guided learning to be completed at the learner's own pace, be up to date, highly interactive and practical. Content of the course modules and topics of the practical training, dedicated to automotive electronics and OBD (On Board Diagnosis) are considered. Results of conducted pilot course with employers in car garages are also discussed.

KEYWORDS: AUTOMOTIVE ELECTRONICS, WEB-BASED AND PRACTICAL TRAINING, EOBD II

1. Introduction

The training needed for car garage and car mechanic qualifications has changed significantly in the past few years. A wide variety of technological developments in the car industry is responsible for this.

Modern cars are as much electronic as they are mechanical, thus creating a new AUTOTRONIC area (AUTOMobile + elecTRONIC). A modern car has several control modules, which monitor and manage most of the major systems in the vehicle. The most common types are engine and drive line control, cruise control, suspension control, anti-lock braking and airbag control, climate control, GPS-based navigation system, stability management system, instrumentation, infotainment, etc. Systems such as 'by-wire' braking and steering systems, collision warning, voice recognition, Internet access, night vision enhancement and collision avoidance systems all start to be introduced. [5,6,7,9]

The growing demands for complex features, including increased safety (brake systems, ESP- Electronic Stability Program), increased comfort (automatic transmission), driver assistance systems (navigation, night vision, blind spot detection) or to comply with legal requirements (reducing the emission of pollutants by intelligent engine control) also increases the demands placed on diagnostics, maintenance and repair. As a result of the growing technical complexity of cars a continuous need to upgrade the technical competencies of car mechanics and employees is emerging [8].

As is the case in all areas of industry, lifelong learning is essential for the workforce, in order to stay viable in markets over the long term. Ongoing car mechanics re-skilling is being pushed ahead in particular due to the following developments:

- The introduction of electronic and communications components from different manufacturers, based on different standards;
 - Increasing technical complexity at the workplace in car garages (introduction of new machines, diagnostic technologies);
 - Increasing competitive pressure on car garages due to the ongoing elimination of market barriers, in particular the automotive block exemption regulation [1] passed by the EU, which weakens the exclusive position of brand-authorized garages and greatly increases the market power of independent repairers, i.e. increases demand for services from independent garages;
 - Decreasing brand attachment on the part of car users in choosing their garages and as a consequence of this, the demand for garages to acquire basic knowledge of Autotronics that can be used for maintenance and trouble-shooting for different brands;

- Preparation for new market opportunities starting as a result of the new European motor vehicle block exemption regulation which will significantly increase competition between independent and brand dealers in the after-sales servicing [2].

While large car garages with exclusive contracts with major car brands are responding to the growing demands for employee qualification with more extensive training budgets and systematic continuing education courses, independent, unattached small and medium size garages are at a structural disadvantage in terms of staff training and development, due to limited financial and staffing resources.

To address these challenges and to fill the gap between current state of car servicing and the requirements of EU regulations an Autotronics (Autotronics is an artificial word-combination of automotive sector and electronics content) course tailored to the needs of small and medium sized car garages and car mechanics have been introduced.

2. Course Structure and Content

The Autotronics course is based on three elements: the e-learning course modules; the traditional classroom practical training; the final examinations.

The course contains a comprehensive suite of three e-learning modules in combination with sophisticated classroom training specifically designed to meet the needs of car garages and car mechanics. These modules are adapted to local requirements, allow self-guided learning to be completed at the learner's own pace, be up to date and highly practical offering interactive multimedia elements.

The e-learning course breaks down into three course modules made up of the following thematic areas.

Autotronics Professional level I

Introduction to Automotive Systems
Electrical Fundamental
Basics of Measurement Techniques
Basics of Automotive Electronics
Basic Hydraulic and Pneumatic Components
Electrical Power Supply in Cars
Practical Training for the Level 1 covers General Electrical System Diagnosis and Services

Autotronics Professional level II

Basics of Sensors and Actuators
Automotive Computers
Gasoline Engine Management Systems
Diesel Engine Management Systems
Practical Training for the Level 2 covers Sensors' and

Actuators' Diagnosis and Services

Autotronics Professional level III

- Emission Control
- On-Board Diagnostic (OBD)
- Road Safety Systems
- Automatic Transmissions
- Electronic Suspension and Steering System
- Communication systems
- Comfort and Safety Systems

Practical Training for the Level 3 covers Live Experiments with scan OBDII Tool

All course modules combine basic knowledge with their specific fields of application in the car industry. The objective of the courses is to impart core competencies applicable across brands in the topics mentioned, supporting users in their day-to-day work on the cars of different manufacturers.

3. Autotronics e-Learning Course Modules

The design philosophy of the Web-based e-learning courses is based on state-of-the-art software technology, which enables the system to operate without interruptions. All system software is based on an open architecture and an open system concept to enable future system expansions.

All course modules are provided to users via the Moodle Learning Management System (LMS) [3]. Moodle is a course management system designed to help educators who want to create quality online courses. Moodle LMS is an open source web-based platform for the administration of learning content, learners and instructors and offers extensive collaboration and communication options such as a forum, e-messaging, newsletter, chat, news and calendar areas. The software is used all over the world by universities, schools, companies and independent teachers.

Moreover Moodle LMS provides the necessary back office function like user management, IPR Management etc. It includes options for teachers to provide user support via chats, forums, etc. It measures how individual learners progress, based on learner tracking and tests. Teachers also have access to information about individual users and their progress (e.g. of assignment) and can contact them directly. All learner data is logged and evaluated, providing the teacher with the option of checking his current level of knowledge in real time.

The course modules that are available in Moodle can be accessed by using any web browser with a modem or LAN (Local Area Network) connection to the Internet [4]. The course modules can be easily changed thus offering content which is always up to date and highly practical. Web-based course providing is flexible and allows learners to select only those learning modules which are appropriate.

All course modules have a multimedia structure and can be displayed on one screen page (no need to scroll). These e-learning course modules provide explanations with the aid of text, animation and also by simulation (require high level of user interaction). At least 80% of the screens are interactive. The interactivity of the animations includes, for example, flipping switches or turning knobs, the drag & drop of various electrical components and placing them to a user-definable workspace, connecting measuring instruments that display values resulting from the connected circuit components. Autotronics circuits can be freely configured and simulated. By pressing accelerating pedal for example a car engine or other car system behaviour can be observed. Each learning unit has case-specific help.

In comparison with traditional classroom training, e-learning courses in the Autotronics course exhibit learner centred features that make learning easier and better tailored to the needs of individual learners and provide excellent support for workforce re-skilling. The e-learning courses are divided into small units, allowing each learner to complete courses based on his speed of learning and individual time budget. Complicated course units can be repeated as often as desired, until course

content enters the user's long-term memory or to brush up on previously learned skills. The multimedia design of the courses simplifies the acquisition of knowledge and regular intermediate tests provide continuous feedback on the user's level of knowledge and progress in the course. These advanced learning opportunities and easy to use courses foster the understanding of the use of Information and Communication Technologies for learning.

3.1 Simulation-Based Training

It is the objectives of electronic control in modern cars to provide the engine torque demanded by the driver, while at the same time satisfy requirements regarding exhaust emissions, fuel consumption, power output, comfort and safety. Mode of operation of major car control systems [5] – [9] are given as examples and learners are guided to understand them by changing operational conditions, and observing system behavior. Simulation approach thus provides the learner with the background to see how electronic controls are applied.

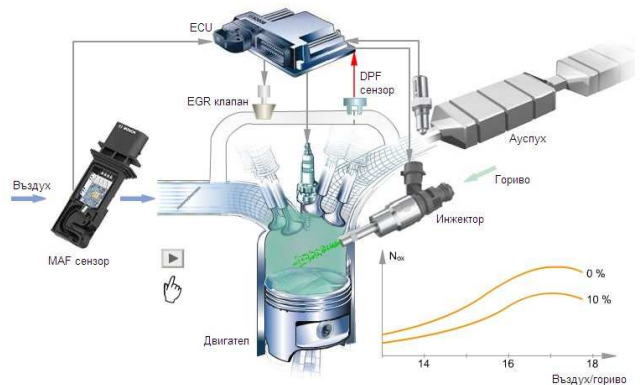


Figure 1 Simulation of Exhaust Gas Recirculation (EGR) system

Fig. 1 shows a simulation example of EGR system operation. By pressing the control button the learner changes the EGR valve position, thus changing the exhaust gas flow entering the engine [6]. All processes are visible – piston movement, quantity of injected fuel, fresh and exhaust air flows, ECU (Engine Control Unit) input signals from DPF (Differential Pressure Sensor) sensor and EGR position sensor and ECU output to EGR valve (modeled as an output from the learner). A brief description of different EGR system modes of operations added in parallel to the simulation. Emphasis is given on the relation between the EGR valve position and the NOx content in the exhaust gasses.

3.2 Virtual Laboratory

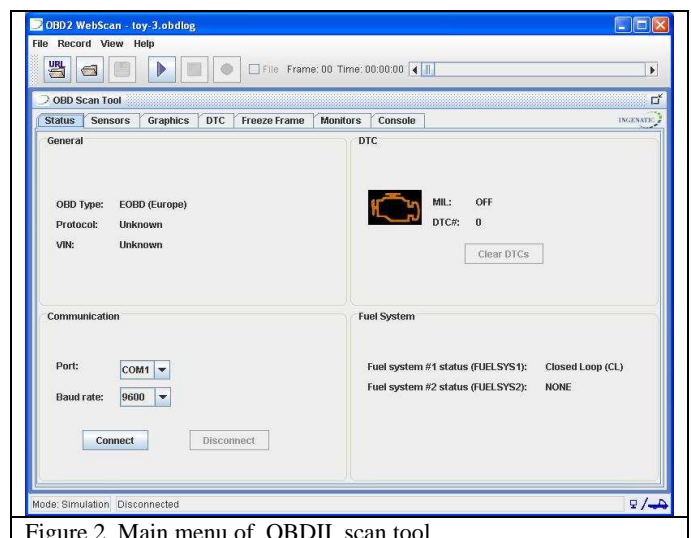


Figure 2 Main menu of OBDII scan tool

A virtual laboratory makes it possible to connect real vehicles to the PCs with the aid of an OBDII interface cable. This means that, in the case of many courses, a bridge can be built between theory and application.

The exercises are focused on the application of the generic OBD test capabilities, found in all modern cars, for diagnosis of typical emission and driveability problems. An advanced OBD-II scan tool is used. In vast majority of exercises the OBD scan tool communicates with a software engine simulator. The last division contains a few “live” exercises – they should be attempted only if your computer is connected to a real car via OBD hardware interface.

4. Classroom Training

The classroom training is provided in well equipped laboratory. Classroom courses are limited to 20 participants each and take place once a week (usually Saturday).

The subjects taught during classroom training correspond to the subjects of the e-learning courses. Moreover, the classroom training provides the possibility to deepen the theoretical knowledge being acquired during the e-learning courses. The topics covered during practical training correspond to the three learning levels as follows:

Autotronics Professional level 1

This level covers such activities as checking circuit resistance (continuity; testing basic electrical/electronic components; performing circuit test – series circuit, parallel circuit – measuring current and voltage, calculating total resistance/impedance, practicing Ohm and Kirchoff law; analyzing waveforms and measure signals values – peak, rms, average, duty cycle, frequency, period; testing circuit with electronic components – diode rectifier, Zener diode voltage limiter, transistor switch in driving circuit; troubleshooting concern opens, shorts and grounds in circuits, existence of unwanted resistances and analyzing AC signal waveforms for fault discovering.

Teaching aims in this module concern learner ability to read and analyze wiring diagrams; creation of learner self-confidence in multimeter and oscilloscope usage, interpret readings and determine needed repair; ability to relate fault in a circuit and reason that cause it.

Autotronics Professional level 2

The second level activities include testing various sensors and their circuits (temperature sensor, throttle position sensor, MAP sensor, Knock sensor, MAF sensor); reading and interpreting automotive manual data; testing actuators with Pulse Width modulation (relay, EGR valve); measuring computer outputs; using diagnosis flowchart to localize trouble in sensor/actuator/circuitry; relate trouble symptom with the reason of its appearance.



Figure 3 Equipment for inductive speed sensor

An example of workbench and measurement equipment for inductive speed sensor is shown in fig. 3.

Teaching aims in this module concern learner ability to read and interpret automotive manual data, ability to choose and apply different testing methods of vehicle sensors and actuators; ability to test and diagnose temperature sensors and their circuits; relate measured data with expected reaction of control modules, ability to test and diagnose different automotive sensors and their circuits; ability to relate troubles with engine behavior, ability to test motors and relate trouble symptoms with reason of its appearance; ability to relate troubles with vehicle behavior, understanding pulse width modulation for controlling actuators.

Autotronics Professional level 3 Specialist

The last level accentuates upon OBD data retrieval and DTC (Diagnostic Trouble codes) diagnosis by using live experiments with scan OBDII Tool.

Teaching aims in this module concern trainees preparation to perform a scan tester diagnosis on a car, their ability to use the scan tool software and hardware to read data from a EOBD compliant car and analyze this data, the learner readiness to create and use symptom charts to set up a strategic approach to troubleshooting problems.

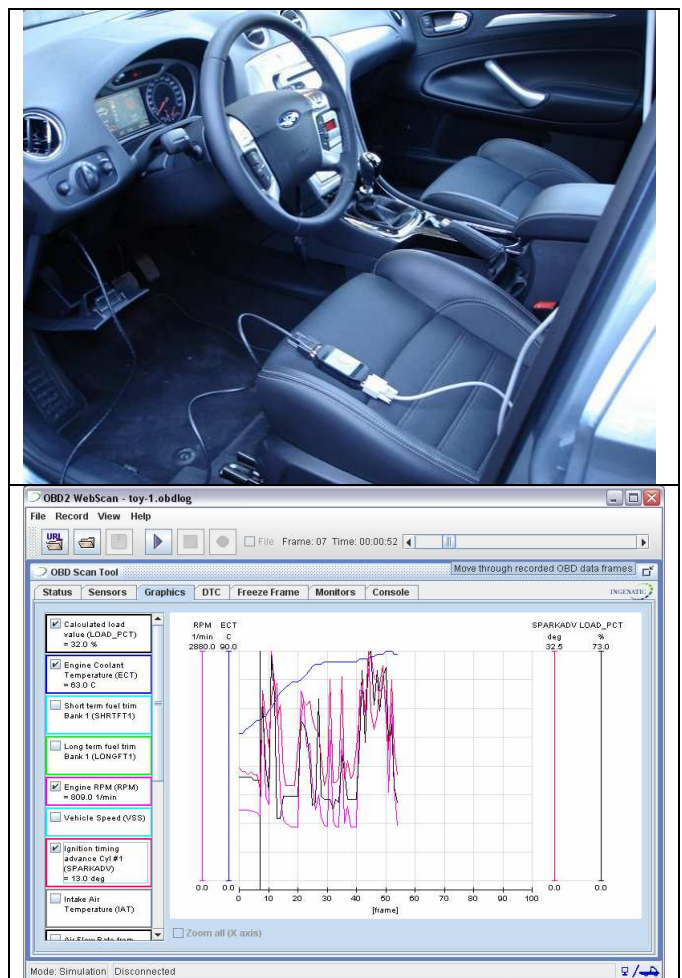


Figure 4 OBDII interface in All New Ford Mondeo and live data monitor of the Scan tool

4. Pilots

The target groups of the Autotronics course are: car mechanics with existing work experience who want to have additional training; small and medium sized car garages who want to train their employees; university Colleges which offer vocational qualifications related to the automotive engineering to students with BTS/apprenticeship and alumnis which dispose of at least three years of working experience;

The three level pilot courses with employers from car garages were conducted. The participants were from small

private family garages, private garage chains; branch authorized garages as well as students from transport faculty. They occupy different work positions – car mechanics, car diagnosis specialists, service managers, garage managers and garage owners.



Figure 5 Fault discovering and repair in electrical circuits during the pilot course.

Past experience with initial pilot users in the courses has shown that the transfer of acquired knowledge to the specific features of different brands was easily possible. To facilitate this transfer, the courses also include brand-specific product details and the comparison of different system solutions/standards of leading car manufacturers to clearly illustrate individual concepts.

Most interesting for participants were trouble shooting experiments and real life OBD diagnosis on EOBDII compliant vehicles. The All New Ford Mondeo and Land Rover Freelander II were used in the OBD diagnostic experiments. By generating false DTC codes and using real data flight recorder the participants were gone through the diagnostic process to the source of the faults.



Figure 6 Discussion on fault trace finding in All New Ford Mondeo

5. Conclusions

The paper considers an innovative approach dedicated to automotive mechatronics education for car mechanics and employers in car garages. It combines the advantages of e-learning courses (individual learner's pace, use of multimedia, etc.) with the vividness of classroom training and the possibility of applying theoretical knowledge acquired directly on the real car.

Structure and content of the Autotronics course with emphasis on automotive electronics and OBD diagnosis is discussed. It offers gaining knowledge in the use of state-of-the-art technology and equipment through deployment of simulation-based training. The e-learning course modules are accessible via an easy to use learning management system which provides chat rooms and forums for learners with similar learning interests, and measures how individual learners progress, based on learner tracking and tests.

The content can be delivered online on the web site worldwide, allowing self-guided learning to be completed at the learner's own pace, from any location ("learning on demand"). This approach significantly reduces training costs compared to classical classroom training (limited expenses for trainers and classroom rent, reduction of travel expenses); reduction in lost labour time at the company based on flexible course participation and class room trainings only once a week (e.g. Saturdays).

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5. References

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