Modern Teaching in the Field of Measurement, Diagnostics and Testing of Vehicles with Alternative Propulsion Using New Technologies

Igor Gajdáč(✉), Tomáš Gajdošík, Ľuboš Kučera, and Branislav Patin

Faculty of Mechanical Engineering, Univerzity of Žilina, Univerzitna, 8251/1, 010 26 Zilina, Slovak Republic
gajdac.igor@fstroj.uniza.sk

Abstract. The article deals with a modern form of teaching the subjects Measurement, diagnostics and testing of machines, Alternative drives, Engineering design III, IV, Innovation of technical systems, which are taught at the Department of Design and Machine Parts at the Faculty of Mechanical Engineering of the University of Žilina in bachelors and engineering studies. The result of the education is not only the acquisition of new information about various measuring systems, diagnostic systems and testing of machinery but also the acquisition of experience from actual measurements performed in laboratory exercises. From the methodological and technical point of view, the laboratory provides a comprehensive laboratory background for testing mobile and stationary drives and vehicle drives, especially alternative car drives for unconventional energy sources. Exercises in the laboratory, as well as practical exercises in a closed test circuit, allow students to understand the issue better and apply the acquired knowledge in practice significantly focused on the automotive industry with the advent of electromobility and other alternative drives, where there is still a high demand for experts in engineering.

Keywords: Laboratory measurement · Measurement methodology · Alternative drives

1 Introduction

1.1 The Current State of Teaching in the Field Alternative Drives

At the Department of Design and Machine Parts, Faculty of Mechanical Engineering, University of Žilina, the study focuses on the area of computer support in the design of technical systems with the main focus on modern methods of computer modelling and optimization. Classrooms are equipped with a wide range of teaching aids and modern display and presentation technology. Students use computer classrooms equipped with powerful computer technology and modern CAD / CAM and CAE systems. In the laboratories of the department, students use unique devices from the field of Bionics,

J. Homišin et al. (Eds.): ICMD 2020, AHE 17, pp. 326–332, 2023.
https://doi.org/10.2991/978-94-6463-182-1_34

Rapid Prototyping, Rapid Tooling, Reverse Engineering and Virtual Modeling. Subjects Design III and IV, Measurement, Diagnostics and Testing of Machines, Alternative Drives and Innovations of Technical Systems are an interconnected group. The aim is to acquaint and prepare students of individual years to understand the principles of power transmission in mobile devices and stationary drives with mechanical, hydraulic, electrical or combined power transmission with a focus on design and calculation of drives and transmissions and new information on measuring and diagnostic systems and testing machines, including experience from real measurements in laboratory exercises. In the field of designing alternative car propulsion, students gain an overview and get acquainted with development trends in innovations of modern technical systems, where unconventional energy sources for the propulsion of alternative vehicles are one of the innovative strategies of technical systems [1–5].

2 Materials and Methods

2.1 Modernization of Teaching the Subject Alternative Drives

The modern concept of teaching with the involvement of new information technologies is important so that the teaching process is not just theoretical. Vehicles that use alternative propulsion using unconventional energy sources are also such an area. In addition, there is not enough study literature on this issue in the form of university textbooks, scripts and procedures for laboratory exercises. Many universities around the world approach a similar problem by introducing a practical part in the form of measurements in laboratory exercises, where students verify the acquired knowledge of various measurement and diagnostic systems, test in practical laboratory exercises or in real traffic.

The implementation of innovations at the Department of Structural and Mechanical Components is still ongoing and requires professional knowledge in the field, pedagogical knowledge necessary to create a methodology for formal and content-based practical laboratory exercises. The preparation of innovation is also demanding in terms of technical support needed to perform laboratory measurements in the form of practical laboratory exercises of students. Ensuring modern test methods of alternative car drives requires mastery of appropriate computer programs, methodological procedures and operation of technical equipment and time.

- The fulfilment of this goal follows the results of research in the field of electromobility, unconventional drives and their components. Research at the department takes place in three interconnected areas: construction of EDISON's own experimental electric vehicle with verification of design, ergonomics and safety elements, the second area is research aimed at optimizing the flow of energy, testing the driving, electrical and mechanical properties of electric and hybrid vehicles;
- The development of an electronic energy assistant for the driver of an electric vehicle with a focus on consumption monitoring to create an energy assistant whose task is not just to calculate the range calculated from the difference between energy received and consumed. The energy assistant performs his tasks before driving while driving up to the charging station. Anticipates insufficient range to the nearest charger, alerts the driver and suggests cost-saving measures;

- Research and development of mechanical and electronic components of electric vehicles using modern construction methods. An example is the currently implemented project APVV-18–0457 Special light electric vehicle made of non-traditional materials for demanding conditions and terrain.

Part of the modernization of the teaching process is the creation of a teaching aid in the form of instructions for exercises aimed at measuring, diagnosing and testing vehicles with alternative propulsion. The teaching process will enable students to understand better the issues of measurement methodology, measurement evaluation, modern alternative drives, the specifics of using unconventional energy sources and finding technical and design solutions to improve the performance and energy performance of drives and transmissions.

2.2 Equipment Needed for Modernization

The MAHA Roller Dynamometer in the laboratory, real-world test equipment and the Edison experimental electric car are used to verify the energy efficiency of unconventional vehicle propulsion:

- Roller dynamometer MAHA MSR 1050 allows you to measure the vehicle with all-wheel drive. It has a swirl brake on the front axles, two swirl brakes on the rear axles and an e-motor on each axle. The diameter of the cylinders is 762 mm, wheelbase from 900 to 2300 mm, max. Axle load 2500 kg, max. Speed 300 km/h, power on the front axle max. 700 kW, power on the rear axle max. 1400 kW, traction force on the front axle 8600 N, traction force on the rear axle 17200 N;
- The Edison electric car is a two-seater small city vehicle of the category Mini, curb weight 1050 kg, max. Speed 90 km/h, range 150 km, rear axle drive, Electric motor is a three-phase asynchronous motor with a maximum power of 30 kW, rated power 16 kW. Frequency converter Curtis 1238 48-80V/550A, Batteries - type LiFeYPO4 300 Ah, stored energy 24 kWh, 2 battery boxes, a total of 25 cells/3.2 V, battery weight 250 kg, BMS control unit with 25 balancers.

Fig. 1. Edison II electric car ready for laboratory and road tests.

2.3 Modernization Process and Sustainability of Innovation

The feasibility of the modernization process in subject teaching and the sustainability of innovation are conditioned by the criteria:

- Simultaneous modernization of the testing workplace and creation of teaching aids;
- Linking theoretical lectures and exercises with practical laboratory measurements;
- Extension of the possibility of measurement in laboratory conditions as well as in real traffic with new laboratory technology;
- Regular maintenance, calibration and innovation of a complex technical system of measuring technology so that it is competitive.

2.4 Implementation Steps

Measurement Methodology

- Collection, sorting and arrangement of used knowledge in the field, preparation of technical solutions for measurements;
- Creation of a set of knowledge from the field of nationally and internationally used regulations in the field of tests and testing of vehicles with alternative propulsion, creation of programs for laboratory measurements in various driving modes.

Laboratory Modernization

- Modernization of the laboratory, addition of laboratory equipment for laboratory measurements of vehicles;
- Modernization of the Edison II experimental electric car, and addition of mobile laboratory equipment;
- Innovation of the operating rules of the testing workplace and implementation of technical safety measures to ensure laboratory exercises for students;
- Test site maintenance planning and implementation of measures to ensure the functionality of measuring equipment, calibration, verification, revision.

Study Materials

- Creation of study materials for laboratory measurements and measurements in real traffic and processing of study materials in electronic form.

3 Results and Discussion

3.1 Measurements in Real Traffic State

The measuring day has two parts, measurement in real traffic and laboratory measurement.

- Measurements for the creation of the Energy Assistant, the influence of climatic conditions, driving style (see Fig. 1);

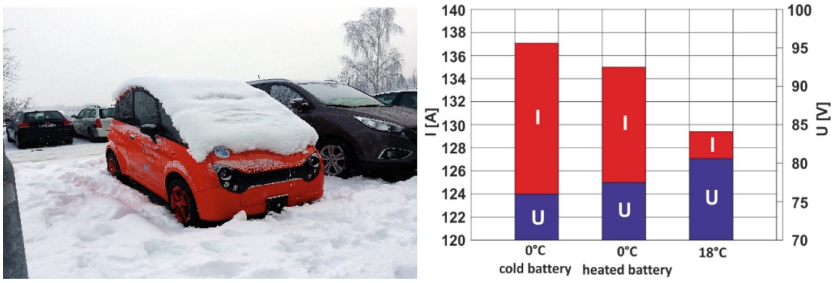

Fig. 2. Example of measuring the influence of climatic conditions on the energy balance of Edison I electric car batteries.

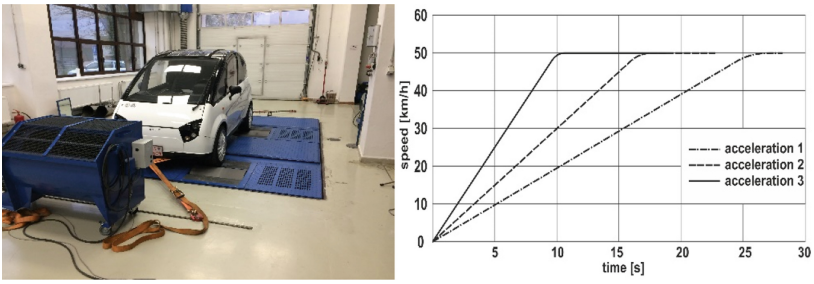

Fig. 3. Example of measuring the most energy efficient acceleration with respect to the efficiency of an electric motor.

- Extending the range of the electric car by correcting the driver's driving style monitoring of energy from the photovoltaic panel.

3.2 Laboratory Measurements

- Deceleration measurements;
- Driving simulation on the WLTP driving cycle;
- Measurements at constant pulling force and constant speed;
- Measurements of drive efficiency and recuperation;
- Measurements of the energy balance of the vehicle in winter and summer tires and at the low and prescribed pressure.

3.3 Test days

The Electromobility Day is organized every year as part of the teaching of the subject Alternative Drives at the Department of Design and Machine Parts. Students can practically try different types of cars with alternative drives: clean electric cars, hybrids, plug-in hybrids. The aim is to make the field of e-mobility accessible not only theoretically but also practically. Students can compare different types of drives and design solutions (Nissan Leaf, Hyundai Ionic, Edison, Kia Soul, Toyota Prius II, Toyota Prius

Fig. 4. Test days.

IV, BMW 225 xe Plug-in hybrid) gain new practical experience and information from areas of e-mobility (Figs. 2, 3 and 4).

4 Conclusions

Innovation and modernization of teaching in the field of measurement, diagnostics and testing of vehicles with alternative propulsion using new technologies will increase the attractiveness of the content of the subject with a link to practical laboratory tasks solved by students. The issue will be processed into a methodologically appropriate form, which can be updated and supplemented. The modernization of existing and the purchase of new measuring equipment will make it possible to expand teaching in the field of measurement, diagnostics and testing of vehicles with alternative propulsion using new technologies. After the completion of the first steps of modernization, the acquired technology and the acquired experience will be continued by updating the already processed and expanding the topic to other related scientific disciplines - parts of machines and mechanisms, construction science, construction technology, etc.

References

1. Regulation (EC) 692 / 2008 NEDC New european driving cycle
2. Regulation (EC) 1151 / 2017 WLTP World harmonizet light-duty vehicles test procedure
3. Pavlovič, J.; Ciuffo B. How much difference in type-approval CO2 emissions from passenger cars in Europe can be expected from changing to the new test procedure (NEDC vs. WLTP)? www. elsevier.com, 20018;96.

4. Roller Dynamometer MSR MAHA manual MSR 1050; BA 053101-de; 2011
5. More, T; Technical Report on EV Laboratory Tests daliverable 5.1; Ghent University; July 2014; Ghent. Available online: www.thomasmore.be