Training in Electrical Machines by Adaptation of Educational Technologies

Antoaneta Dimitrova

Trakia University, Faculty of technics and technologies,
38 Graf Ignatiev srt., 8602, Yambol, BULGARIA,
e-mail: adimitrova77@abv.bg

Abstract:
Harmonization and integration within the European Education Area is needed for training in the field of electrical machines. For this purpose, the curricula and programs, providing fundamental, general technical, specialized engineering training, must correspond to the level of development of modern theory and practice in the specific subject area. The article presents an analysis of the adaptation of digital teaching materials and technical tools in the engineering-laboratory courses in the training of electrical machines. A methodology has been proposed through which these teaching materials and technical tools become a useful apparatus for achieving better student engagement in the learning process. This will require continuous additional efforts on the part of the teaching staff and constant updating of their specific digital competencies.

Keywords: Electric drives, Interactive tools, Electrical machines, Experimental equipment

1 Introduction

Modern education is reduced to the acquisition of a number of knowledge gained from practical and laboratory exercises (Zlatev et al., 2018; Georgieva et al., 2018). With the development of science and technology, the requirements for the technical and technological tools necessary to obtain this knowledge also increase. (Pehlivanova et al., 2011; Nedeva et al., 2013; Georgieva et al., 2015). For this purpose, the training must be carried out according to specially created curricula and programs. They provide the necessary fundamental, general technical and special engineering training. Purposefully, they must correspond to the level of development of modern theory and practice in the specific subject area (Mladenov et al., 2008; Pehlivanova, 2015). This statement was confirmed in the comparative analysis between the disciplines set in the curriculum of the specialty "Electrical Engineering" at the Faculty of Technics and Technology, Yambol, Bulgaria (FTT). The comparative analysis was made with technical universities in Bulgaria, Greece, Australia, Germany, Great Britain.

Figure 1 presents the results in the search for coincidence of disciplines studied in FTT with those from other universities in Bulgaria and abroad. It can be seen that the coincidence of the studied disciplines is over 60% for the universities in Bulgaria. This is because the curricula in FTT are in line with the requirements of business in the city of Yambol and the region. As can be seen from the graph, the results are similar compared to universities outside Bulgaria (over 50%). The main coincidences are in the studied technical disciplines.

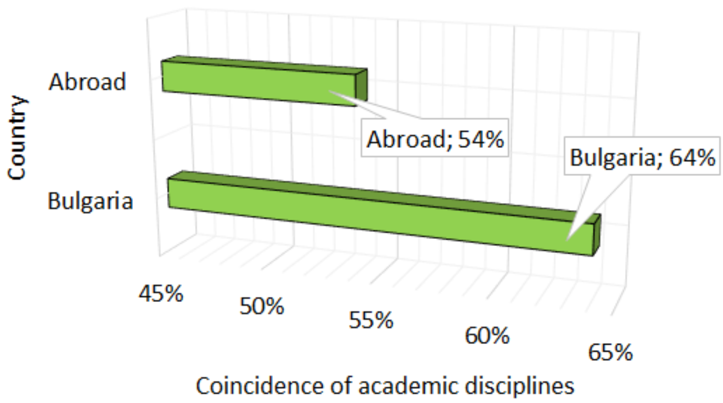

Figure 1. Coincidence of disciplines studied at FTT with those from other Universities in Bulgaria and abroad

Both abroad and in Bulgaria, the main place in the training is occupied by the practically oriented disciplines. Active forms of education have a significant relative share in the education in the specialty "Electrical Engineering" and in particular in electrical machines and enable students to independently solve individual problems of practice. For this reason, it is necessary to provide modern technical tools for students to work with.

Under European programs, experimental productions have been acquired at Bulgarian universities, mainly from producers in EU countries.

Bulgarian technical Universities have a tradition in training in the use of electrical machines. For effective use of the experimental productions it is necessary for them to be adapted to the teaching methods in Bulgaria (Zlatev, 2017; Doncheva et al., 2018).

The purpose of the report is to propose a methodology for adapting experimental setups to the needs of training in electrical engineering in Bulgaria, which will be suitable for e-learning and distance learning.

2 Material and methods

Lucas Nuelle training systems (Lucas-Nuelle, Inc., Germany), delivered under project BG161PO003-1.2.04.0081-C001 are used during the training in the discipline "Electrical Machines" at the Thrakia University (TrU), Faculty of Engineering and Technology, Yambol, Bulgaria. "Development of research and development capacity of TrU through renovation and modernization of applied research equipment".

Each of the studied machines is attached to a circuit board, which is placed on the laboratory installation and connected via a USB connection to a computer and the LabSoft multimedia interactive environment (Lucas-Nuelle, Inc., Germany). This software product provides virtual measuring instruments, and each of the measured values in real time can be checked for correct reading. The work window is divided into two parts.

In the left part is presented the studied course in the form of a short theoretical part and exercises, and in the right part their visualization, including scheme and way of connecting the experimental setup, setting of the used virtual tools, tables for filling, questions related to the specific exercise. There are laboratory exercises studying the following electrical machines: single-phase and three-phase transformer, autotransformer - Three-phase transformer SO4204-7Y; three-phase asynchronous motor with short-circuited rotor - Asynchronus mashines SO4204-7T; three-phase asynchronous motor with wound rotor - Slip-ring machines SO4204-7U; DC motor, universal collector motor - DC machines SO4204-7S; synchronous motor Slip-ring machines

SO4204-7U; stepper motor- Stepping motor SO4204-7W. A strobe for measuring the speed is provided for each of the considered electric motors.

Also, a laboratory stand is used for energy efficiency testing in electric drives, consisting of the following separate modules - power supply unit CO3212-5U, frequency inverter for control of asynchronous motors from Lenze (Lenze SE, Aerzen, Germany) CO3636-5G, CO3636-5V, test system with servomotor-CO3636-6V, multimeter with the ability to measure active, reactive, full power, current, phase voltage of the studied induction motor, cosφ; asynchronous motors-energy inefficient-SE2673-1K and energy efficient IEE 3-SE2673-1N.

3 Results and discussion

The individual stands used in the training are adapted to the study curriculum in the discipline of Electrical Machines, in order to effectively apply them and obtain specific knowledge, skills and competencies from students.

This is possible due to the accurate and clear visualization of each specific exercise, the simplified setup of the used virtual instruments for measurement and monitoring, the ability to check the measured values and the observed dependencies. In this way, the trained students acquire skills with a practical focus, giving them the opportunity to form the right behavior in real working conditions.

Table 1 presents the topics of the curriculum in electrical machines and appropriate experimental settings for the implementation of exercises.

The laboratory unit examining the characteristics of a single-phase transformer allows the operation of a single-phase transformer to be monitored in idle mode, measured by a virtual ampmeter and a voltmeter-idle current of the primary coil, voltage of the secondary coil terminals. A virtual oscilloscope visualizes the spurious form of idle current. The single phase transformer is tested both in load mode and in case of short circuit. Important characteristics such as nominal short-circuit voltage are identified, the influence of the type of load on its operation is monitored.

The three-phase transformer study involves tracking its operation on different circuits and groups of primary and secondary winding. The tests are carried out in a symmetrical and asymmetrical load.

When studying the operation of an autotransformer, it is monitored the decreasing and increasing voltage transformation without load and the load of the autotransformer.

The study of a three-phase asynchronous motor with a squirrel-cage rotor is accomplished by two laboratory installations - UniTrain INTERFace, together with Asynchronous machines and an energy efficiency testing stand in electric drives. An asynchronous motor is captured by the stand. Also, on the basis of the laboratory installations, knowledge of the types of stator winding of an asynchronous electric motor, reversing, use of variable frequency drive (VFD) and adjustment is obtained.

Table 1. Curriculum topics and appropriate experimental setups

Subject	Laboratory equipment
Exploring the characteristics of a single phase transformer	Three-phase transformer SO4204-7Y
Exploring the characteristics of a three-phase transformer	Three-phase transformer SO4204-7Y
Exploring of autotransformer	Three-phase transformer SO4204-7Y
Examination of the characteristics of a three phase asynchronous motor with a squirrel-cage rotor	Asynchronous machines SO4204-7T Laboratory stand - CO3212-5U,CO3636-5G,CO3636-5V,C03636-6V,CO5127-1Z,SE2673-1K,SE2673-1N

Examination of the characteristics of the three-phase asynchronous electric motor with wound rotor	Slip-ring machines SO4204-7U
Insertion of a three phase asynchronous motor with squirrel-cage rotor to a single phase network	Asynchronous machines SO4204-7T
Exploration of a DC motor	DC machines SO4204-7S
Exploration of a universal collector electric motor	DC machines SO4204-7S
An asynchronous electric motor study	Slip-ring machines SO4204-7U
Examining a stepper motor	Stepper motor SO4204-7W

An asynchronous wound rotor motor test involves starting the asynchronous electric motor by engaging resistors in the motor rotor circuit and setting the shunt time. The sliding and rotational speed of the asynchronous electric motor is calculated, the measured and calculated quantities checked.

An example of realization of a practical exercise, in which the dependence of the the stator winding parameters current and impedance of phase, at different voltage frequencies is monitored and the elements of the equivalent circuit of the induction motor are determined.

The tasks that students have to perform include connecting the scheme, measuring, recording and analyzing the results obtained.

The scheme of the experimental staging is gradually connected, in a way set in the exercise in the form of animation.

Initially, the tested phase of the stator winding is connected to a DC source, which is adjusted according to the instructions. The measuring instruments - Voltmeter A and Ammeter B are also switched on and adjusted.

The voltage of one phase of the stator winding and the current through it is measured. Using the obtained values, the active resistance of the stator winding phase is calculated.

The next measurement is made at a power supply of alternating voltage and adjustable frequency. The results are recorded in a table. The dependence of the current and impedance of one phase of the stator winding on the frequency is monitored. Based on the values obtained at a frequency of 50 Hz, the inductance of the respective phase of the stator winding is also calculated.

a) Laboratory setup – general view b) Screen of exercise realization

Figure 2. Stage of an exercise to study a three-phase induction motor with a wound rotor

When studying the connection of a three-phase asynchronous motor to a single-phase network, the start-up is done by pre-connecting the stator winding in a triangle and the motor being switched on as a single-phase capacitor motor.

In the DC motor test, a sequential, parallel, mixed coupling of the excitation coil to the anchor winding is carried out, measuring the speed of rotation. Laboratory setup and paced exercises allow you to adjust the rotational speed of a DC motor by: changing the supply voltage, adding additional resistance to the boiler circuit, and changing the excitation current. Through a virtual oscilloscope, the starting current is monitored and reported when the DC motor is started directly and by means of resistors in its anchor chain. Reversing the DC motor by changing the direction of the current in the excitation or anchor coil is also realized.

The universal collector motor study is performed by determining the useful moment of the rotor shaft, taking the losses from the rotor steel in rotation and the mechanical losses at the respective speed from the electromagnetic power.

The study of a synchronous motor through the laboratory setup gives a clear understanding of the start-up process of these engines and the lack of starting momentum in them. The release is realized through frequency feed. Determine the cos φ of the engine studied.

When studying a stepper motor, determine the maximum frequency of the stepper motor in which it can be actuated and reaches each position. The control signals are examined in full-pitch mode. Reversing the stepper motor is realized.

The adaptation and implementation of new training stands ensures independent performance of practical tasks by students as main learners. Affordable hardware is used, which reduces equipment and maintenance costs. Students are given the opportunity to work independently, which leads to the improvement of skills that are defined in the learning objectives.

When adapting practical exercises, it was found that the experimental setups are suitable for solving various practical tasks close to working in real production conditions. Through them, students acquire skills in using electrical machines in real production processes. Based on the realized examples in the present work, the adapted exercises are added to the existing course for electrical machines of the students in FTT Yambol.

4 Conclusion

The use of modern teaching tools requires constant additional efforts on the part of the teaching staff and constant updating of their specific and digital competencies.

The curriculum in Electrical Machines at the Faculty of Technics and Technology is harmonized with those of related specialties in other Bulgarian and foreign universities in terms of content and basic parameters. This is an important condition both for the realization of student mobility and for integration into the European educational area.

From the management point of view, there will have to be additional funds and infrastructure.

The developed methodology and support tasks will be applied in a number of exercises on electrical machines. Educational goals were set for the respective curriculum, which the learners must achieve.

The research can be continued by conducting a survey among students in order to evaluate the effectiveness of the use of the proposed methodology.

References

Doncheva, J., Ivanova, E. (2018): Contemporary challenges and expectations of inclusive education in the republic of Bulgaria. In *VI International Scientific Conference 'Contemporary Education – Condition, Challenges and Perspectives'*, Goce Delchev University - Shtip, May, 11-12, 2018, 152-160

Georgieva, K., Stoykova, V., Ivanova, N., Dimova, E. (2015): Application of information technologies and interactive tools for improving educational quality. In *CBU International conference on innovation, technology transfer and education*, March 25-27, 2015, Prague, Czech Republic, 468-474.

Georgieva, Ts., Gueorgiev, Tz., Kadirova, S., Evstatiev, B., Mihailov, N. (2018): Analysis of using digital learning materials in engineering laboratory courses. *Journal of Engineering Studies and Research*, 24, 1, 24-29.

Mladenov, M., Popova, M., Lehov, G. (2008): The Training in Automatics, Information and Control Engineering at Ruse University. In *Proceedings of University of Rousse*, 47, 3.1, Bulgaria, 217-221.

Nedeva, V., Dineva, S., (2013): Design and development of efficient e-learning courses. In *International conference of virtual learning,* ICVL 2013, Romania, 108-115.

Pehlivanova, M., Ducheva, Z. (2011): Training in a virtual learning environment in the theoretical module - a factor for development of "responsible" driver. In *International Conference on Virtual Learning*, ICVL 2011, Romania, 275-280.

Pehlivanova, T. (2015): Methods for intensification of the training in technical subjects. *Applied researches in technics, technologies and education* (ARTTE), 3, 4, 344-349.

Zlatev, Z., Bayceva, S (2017): Application of educational technical tools for analysis the color of essential oils from white oregano. In *Proceedings of the 12th International Conference on Virtual learning* (ICVL 2017), Sibiu, Romania, 141-144

Zlatev, Z., Bayceva, S (2018): Application of optical device in methodology for teaching analysis of essential oils. In *Proceedings of the 13th International Conference on Virtual learning* (ICVL 2018), Alba Iulla, Romania, 124-129