Interactive Laboratory Research of Variable-Frequency Electric Drive at the UMMC Technical University

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Abstract. The article describes the experience of performing interactive laboratory work at a corporate university on the basis of a smart laboratory of an automated electric drive using the example of the study of an asynchronous frequency-controlled AC electric drive. The developed technology contributes to training of engineering personnel ready to face urgent production challenges without additional onboarding on-site in programs of higher education. The article explains the definition of "interactive teaching" and gives an overview of the methods of its application, including a corporate university. The example of interactive laboratory work demonstrates methods of interaction "teacher - student - smart laboratory", providing the student with a technical and creative environment for solving a production case, including digital data of enterprises.

Keywords: interactive training, programs of higher education, applied baccalaureate, corporate university, smart laboratory, digital data of enterprises, interactive laboratory work, variable frequency drive.

1 Introduction

The engineers' work in the context of the development of digital production requires the ability to effectively solve various production tasks, to find innovative solutions, to streamline the experience, including being ready for new activities, being proactive and keeping ahead of the game.

At the same time, against the backdrop of a corporate university, including technical university (hereinafter TU), professional competencies are developed in the format of production objectives that students must reach through understanding in the learning process.

Therefore, an important aspect of TU activities is the creation and application of such an approach to the implementation of educational programs that would take into account the requirements for the competence of the graduate, ensure his willingness to solve leading tasks on the one hand, and prevailing of corporate features on the other.

Currently, the university has created smart laboratories, where interactive laboratory researches are performed.

The article describes the experience of performing such laboratory research work as a case study of an asynchronous frequency-controlled AC electric drive.

2 Interactive Teaching

The UMMC Technical University implements applied bachelor's and applied master's programs in the field of Electrical Power Engineering and Electrical Engineering. From the first year, every student is motivated to perform final qualification work for the company's enterprise with its further implementation into production.

The education in the corporate university is fully controlled by a business partner (Holding, enterprise), which requires for new staff. The educational program in this case is agreed with the business partner, and the formation of competencies is implemented in real production conditions of a particular enterprise.

Active or interactive methods of teaching only [1-5] can give good results when implementing such programs.

The term "interactive" originates from two words "inter" and "act" and means having the ability to act upon or in close relation with each other, to be in the conversation or dialogue mode with something (for example, a computer) or somebody (a person). First of all interactive teaching means dialogue-oriented teaching in course of which the collaboration proceeds [6].

Features of interactive teaching have been recently developed, such as person-to-person dialogical interaction in "teacher-student" and "student-student" systems; cooperation in small groups; active simulation (role-playing) and training in teaching process [7].

There is a large number of publications devoted to development of interactive teaching methods and forms of their implementation.

Among the methods, the following are worth mentioning: brainstorm, lessons with audio- and interactive video materials and electronic aids, round tables (discussions and debates), organizational-activity games, project methods, work in small groups, case methods enabling to simultaneously integrate theory and practice working on an actual production task etc. [7-16].

In terms of this article, interactive laboratory work means dialogical interaction to solve production cases in educational information system "student – teacher - smart laboratory".

Specific features of UMMC TU laboratories are the following:

- Data communication among laboratories;
- Integration of physical and 3D-models of technological equipment with mathematical "plot" of their work process, including digital data of enterprises;
- Availability of web-interface for automatic generation of laboratory research reports and for provision of remote access to laboratory equipment;
- Availability of 3D-simulator for training staff to act in emergencies.

As a result, the laboratories present a unique system with unique set of the following modules:

- Technological process module (digital twin of the production);
- Trainings;

- Educational process monitoring module;
- Training startup and monitoring module;
- Training editing module;
- Voice interaction in the process of training;
- SCADA operation;
- Communication with SCADA systems;
- Data output to AR;
- Objects arrangement in 3D-space of “digital copy”;
- Loading of new 3D-objects to “digital copy” (fig.1) [17].

Fig. 1. Smart laboratory of automated electric drive.

This article illustrates how to put interactive teaching into practice in the smart automated electric drive laboratory, which allows conducting studies as follows:

- Studies of different AC/DC VFD modes, Training editing module;
- Task modelling as per selection of an energy sustainable type of electric drive based on research into and comparative assessment of different electric drive features in terms of energy efficient operation and control modes;
- Task modelling: specific aspects of commissioning, maintenance and control system troubleshooting based on different FCs.

Industrial FCs, software, PLCs and instruments, available in the laboratory, allow simulating production-relevant experiments within laboratory practicals.

A well-designed web-interface makes it possible to build an effective online and remote interaction between lecturers and students.

An example of the way production cases solutions are arranged is that students, pursuing applied bachelor's degree program, have to study AC asynchronous VFD operated in all UMMC Group enterprises.

Undergraduates undertaking a program on "Electric equipment and facilities of mining and industrial companies" perform laboratory works on solving production cases such as optimization of operation modes of asynchronous VFD with a FC - SB-19 (substantiation of vector or scalar control of electric drive modes, provision of electromagnetic compatibility with supply mains and load).

3 Interactive laboratory works in UMMC TU

Let us consider the way interactive laboratory work is arranged. There is a task to provide electromagnetic compatibility with supply mains and asynchronous AC VFD.

Electromagnetic compatibility disruption may result in failure-related functional disturbances, reductions in service period, equipment breakdown, defective products, emergencies, malfunctions of automatic protection devices, etc., which proves practical relevance of the task tackled by students.

Students can master basic theoretical material prior to performing laboratory work assigned by a lecturer by accessing XLab.LMS web-interface (Fig.2, 3).

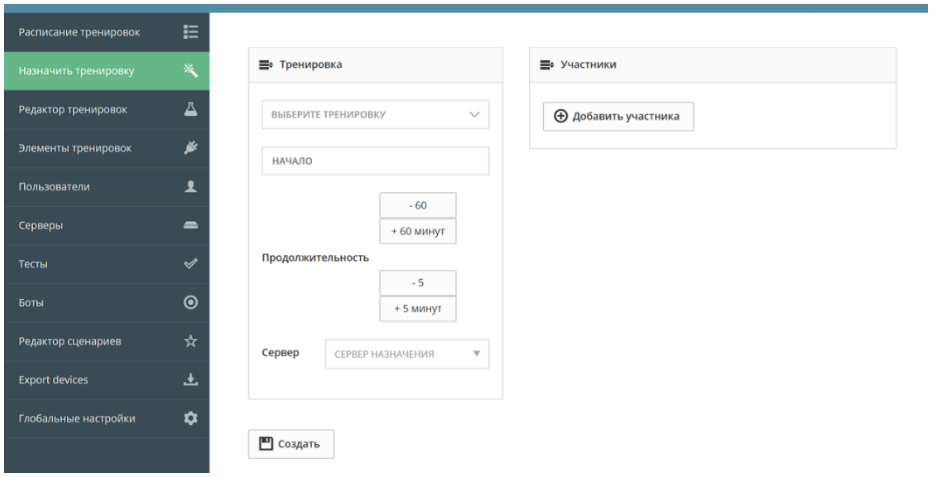

Fig. 2. Window with a lab work assigned by a lecturer to a student.

Laboratory activity begins with a dialogue between a teacher and students, whereat they assess the degree of their readiness to perform laboratory work, set the main goal and objectives and model the research program.

Thereafter, students are arranged to practice directly at the laboratory bench in such a way that, in addition to practice, for the foregoing purposes, they also need to advance in knowledge while using the laboratory bench (Laboratory Bench Manual), the Visual Engineering Tool software package for monitoring the status and parameters of the SB-

19 frequency converter (VET Software Manual), Rigol MSO 1104Z oscilloscope (Digital Oscilloscope User Manual). Moreover, when setting a frequency converter, they need to scrutinize the documentation for SB-19 inverter.

Fig. 3. Log in XLab.LMS.

Thus, workplace environment for setting up an electric drive is simulated for students.

One of the options for solving the case is to use a line choke during the experiment and to obtain input current oscillography chart in the input power circuit.

Students should use the obtained oscillograms to justify the installation of the line choke, which is a buffer between the power supply network and the frequency converter protecting the network from higher harmonics 5, 7, 11, etc. (Fig.4, 5).

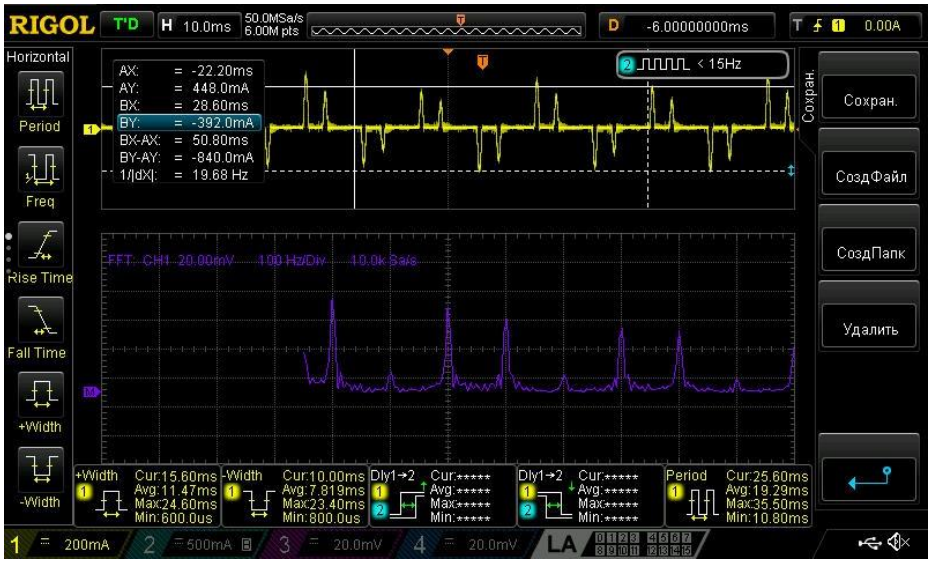

Fig. 4. Oscillograms of input current without line choke.

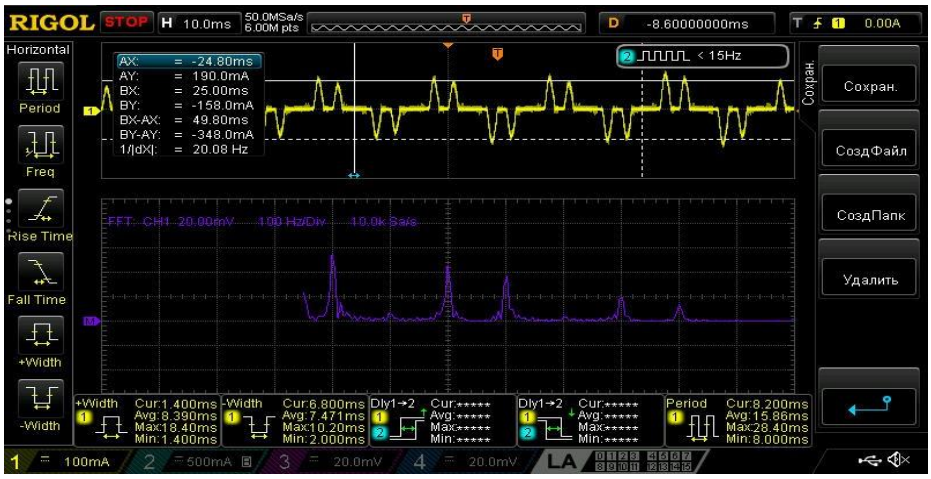

Fig. 5. Oscillograms of input current with line choke.

In the course of implementing the program, the teacher-student dialogue is periodically resumed at different stages, e.g. when checking experimental designs, tuning instruments, setting the frequency converter, and discussing the case solution.

Using the XLab.LMS system, students generate a laboratory report, which is automatically transfered to the teacher, who can assess the performance of work directly in the classroom.

The duration of interactive laboratory classes can be 6-8 academic hours. As a result, there is a deep immersion in practical activities, which contributes to the formation of professional engineering competencies in accordance with the professional and corporate standards of the employer.

4 Conclusions

Smart laboratories help to establish technical and creative environment for the implementation of production cases at UMMC TU.

The developed laboratory technique serves the purpose of increasing the effectiveness of engineers' specific training for UMMC.

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