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POSSIBILITIES OF APPLICATION OF VIRTUAL LABORATORY COMPLEXES ARE AT THE STUDY OF NATURALLY-TECHNICAL AND HEALTH DISCIPLINES

Summary. *The methodology of laboratory work with the use of computerized laboratory stands in teaching disciplines of natural science and health areas is proposed.*

Key words: *bench equipment, computerized complexes, laboratory work, virtual complex, biomethanogenesis.*

Introduction. Modern world educational trends confirm that the use of new informational means makes it possible to achieve fundamental changes in the quality of education. At present, educational institutions have a large number

of computer equipment, which is somehow involved in the educational process. However, specialized laboratories are usually not equipped with computer hardware, which greatly reduces the possibilities of hands-on courses. The creation of computerized laboratory complexes gives the possibility of carrying out a wide range of work on one complex, which, in turn, solves the problem of insufficient laboratory hardware [1; 2].

The purpose of the work is to create scientific and methodological bases of methodological support in the implementation of multilevel educational technologies using computerized systems [3; 4].

Realization of the set goal will allow solving the following tasks: the possibility of modeling and predicting the parameters of various technological processes; implementation of preliminary test studies of electromechanical and biotechnological processes; determination of the optimal parameters of the working equipment [5; 6].

Equipment and research method. The digitalization of higher school development creates the advanced conditions for the transition to the training of both national economy specialists and Masters to replenish scientific and pedagogical staff. The masters' training level must be significantly higher than that of the specialists'. This is possible to be achieved with the appropriate, fundamentally new, laboratory base, implemented taking into account several fundamentally new requirements:

   – the research amount performed at the laboratory complex should cover most of the technical disciplines provided by the curriculum;

   – laboratory hardware must meet the requirements of the work planned to be carried out by degree-seeking students and lecturers, that is be part of the research equipment of the department for its long term development;

   – the equipment should be as consistent as possible with the level and directions of technical progress in the main national or regional industries;

   – the equipment should be integrated, wide in functionality, include

elements to expand the intellectual and cognitive aspects in the problematic issues study;

– the equipment should be affordable for almost any educational institution for the training of bachelors and masters in electromechanics [1–6].

The efforts aimed at the creation of such equipment after more than ten years of research and experiments have led to the understanding of the depth and importance of this problem and ultimately to the creation of non-standard equipment which meets these contradicting requirements.

Results and discussion. The established idea is that based on electromechanical equipment available in any institution of higher education, computerized complexes are created which include, in addition to electric machines, a personal computer of sufficient level, analog-to-digital and digital-to-analog converters, branched sensor systems for monitoring electrical and mechanical quantities. As a result, the following options are available for the research:

– electromechanical converters (electric machines);

– converting equipment devices;

– microprocessor equipment and computer control devices elements;

– –automated electric drive systems elements (controlled quantities sensors);

– branch software for creating mathematical models, the use of the known ones for its intended purpose;

– apparatus for self-study, mastering technical English as a basis for computer technology, software language and the use of the Internet.

The current state of the bench equipment is unsatisfactory, both from the standpoint of conducting research work and from the standpoint of organizing the learning process that meets the manufacturing requirements.

The electric drive qualitative parameters and characteristics improvement is achieved due to the use of complex control algorithms implemented on

microprocessor technology devices. Such requirements research and study allow us to create more complex operation algorithms and develop more advanced devices that allow them to be implemented [1–6].

All the factors mentioned above set the task of creating and practical implementation of new generation bench equipment, the implementation of which will allow studying the processes occurring in the electric drive deeper, both at the level of the qualitative characteristics and at the level of the quantitative indicators, and thus to expand the research issues range. At the same time, the methodological support issue arises, which will facilitate the understanding of the scientific and technical importance of the studied elements, systems and devices.

For that purpose, a set of laboratory benches has been created, which allows to solve a number of problems and eliminate the shortcomings of existing laboratory research equipment.

The availability of sophisticated control systems for converter installations and computerized measuring systems makes the benches universal, as well as increases the requirement level concerning the researchers' initial knowledge and their ability to work with complex equipment. The computerized system flexibility and the availability of the measuring sensor allow the complex control systems to be implemented. Changing operation structure and algorithms can be performed by changing the appropriate program or the sequence of programs. The researcher must be able to use software and hardware [4–7].

The most important part of the appropriate computerized systems use is to determine the amount of laboratory work that can be effectively carried out, the peculiarities of creating methodological support for the whole research complex, taking into account the generality and peculiarities of each laboratory work. At the same time, it is possible to allocate a number of feature characteristic of the developed complexes, but not of the available standard bench laboratory equipment, which is the following: the number of courses for which a possible

laboratory workshop is quite large; requirements for individual sets of works can be unified and each of them must be a separate part of the whole software product; the amount of the resulting methodological support might occur to be so large that its use is possible only if the software product is created on the principle of step-by-step units (a measurement unit, a control unit, etc.).

Thus, it is rational to structure both the methodological support and the laboratory work. The problem solutions concerning the creation of methodological support in the minimum possible time are possible by coordinating the subject direction of the measurement unit used. The analysis of the laboratory workshop for electrical engineering shows that only some part of the works [4; 5; 7] can be performed using laboratory complexes.

Rejection of a number of works is performed based on the fact that the works are of a special nature (study of the design of particular, not included in the equipment set design, the study of the particular components interaction principles). Based on the principle mentioned above, 31 works were selected for the analysis, which are included in the hands-on course of 11 disciplines. The initial stage of creating methodological support for computerized laboratory complexes is to develop a unified universal algorithm for laboratory work on computerized laboratory complexes (Fig. 1).

The algorithm includes several main blocks:

– admission to laboratory work;

– preparation for laboratory work carrying out;

– experiment conducting;

– obtained results processing;

– laboratory work defense.

Admission to laboratory work involves the test of knowledge required to perform this laboratory work and it is carried out using a personal computer. The admission starts with the test of safety knowledge and possible emergency conditions.
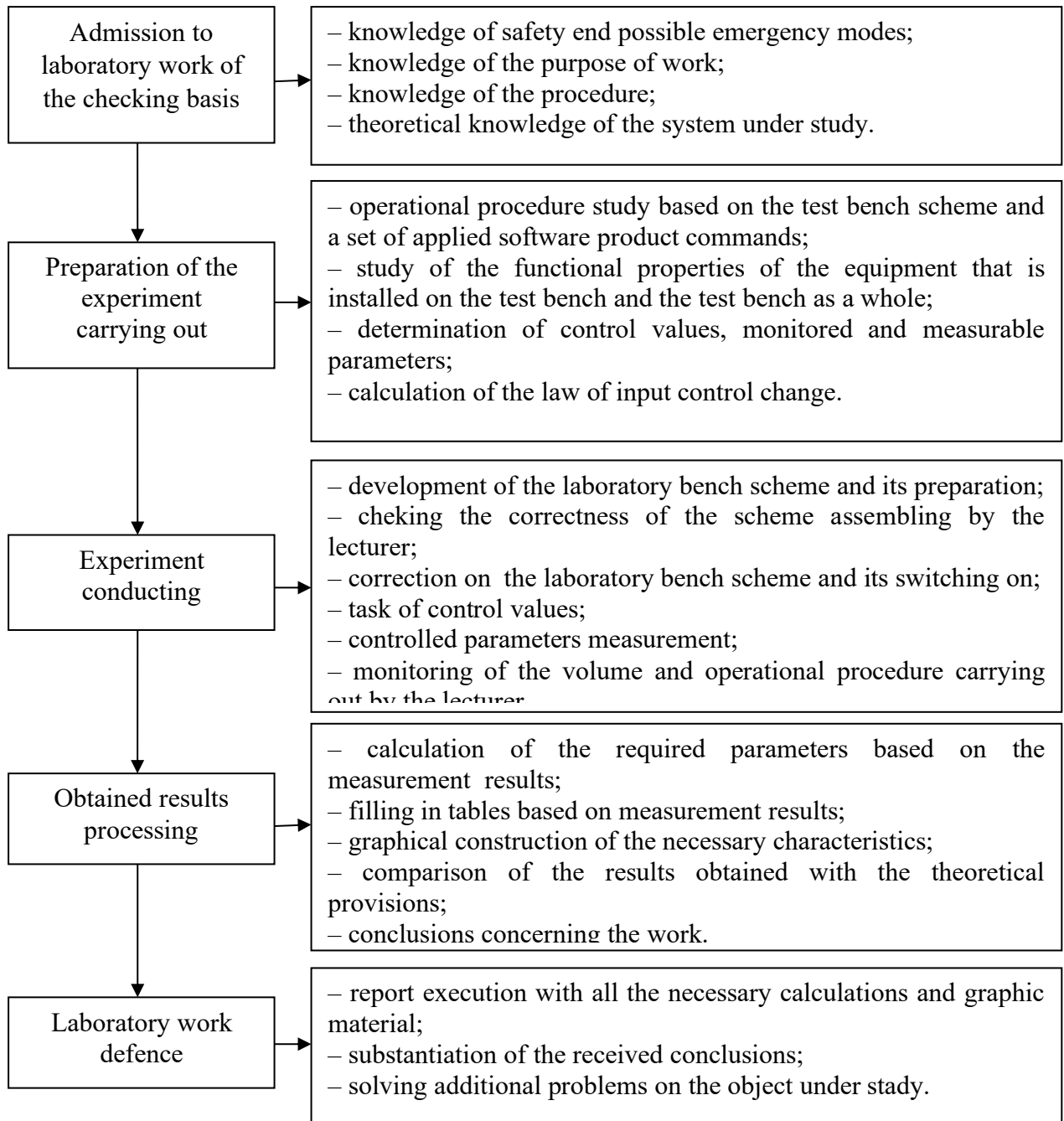
| Admission to laboratory work of the checking basis | – knowledge of safety end possible emergency modes;
– knowledge of the purpose of work;
– knowledge of the procedure;
– theoretical knowledge of the system under study. |

| Preparation of the experiment carrying out | – operational procedure study based on the test bench scheme and a set of applied software product commands;
– study of the functional properties of the equipment that is installed on the test bench and the test bench as a whole;
– determination of control values, monitored and measurable parameters;
– calculation of the law of input control change. |

| Experiment conducting | – development of the laboratory bench scheme and its preparation;
– cheking the correctness of the scheme assembling by the lecturer;
– correction on the laboratory bench scheme and its switching on;
– task of control values;
– controlled parameters measurement;
– monitoring of the volume and operational procedure carrying out by the lecturer. |

| Obtained results processing | – calculation of the required parameters based on the measurement results;
– filling in tables based on measurement results;
– graphical construction of the necessary characteristics;
– comparison of the results obtained with the theoretical provisions;
– conclusions concerning the work. |

| Laboratory work defence | – report execution with all the necessary calculations and graphic material;
– substantiation of the received conclusions;
– solving additional problems on the object under stady. |

Fig. 1. Algorithm for laboratory work on a computerized laboratory complex

Source: authors development

Check questions are selected for each work separately (about 10 questions). Answer options are offered, among which there is the correct one. The student gets points for the answers, for example, one point for the correct answer, no points are given for wrong answers. Then, in the conclusion of the safety test, the results are recorded in a summary table of results, which

indicates the answers to each question, the date and the test checking time.

This way, the lecturer can review all the answers to the questions and find out what exactly the student does not know. All attempts results are recorded. In case of more than three attempts, the lecturer can conduct an oral interview to rule out random answers. If the student has not passed the first question block (safety check), he is not allowed for further check. Having a positive result of the safety knowledge test, the student proceeds to the next section of the knowledge test procedure. Testing knowledge of the laboratory work procedure begins with the question about the purpose of the work. Next, it is required to specify the standard operating procedures where there are several possible options proposed, where optional equipment plugging-in sequences are indicated. Having answered correctly to the question proposed, the student goes on to the next section of the admission to laboratory work.

The proposed algorithm for laboratory work carrying out was tested within the framework of the Alternative Energy Sources course for degree-seeking students in electromechanical specialties using the LabVIEV graphical environment [4; 5; 7].

As the basis, a virtual laboratory complex was taken to evaluate the efficiency of obtaining biogas from various plant raw materials for automation and biomethanogenesis management [4; 8–11]. At the same time, the functions of ensuring the virtual laboratory bench operation were developed separately for each alternative energy source: setting influences, control elements (mode select switches – cyclic or automatic); process parameter indicators (temperature – $T1$, $T2$; volume – V; process time – t, concentration – C), indication and results display.

The choice of the bench operation mode, the initial conditions task and the automation block diagram (Fig. 2) were identical, given in [2; 4; 9; 11]. A separate block stands for forming a table of obtained experimental data (Fig. 3–5).
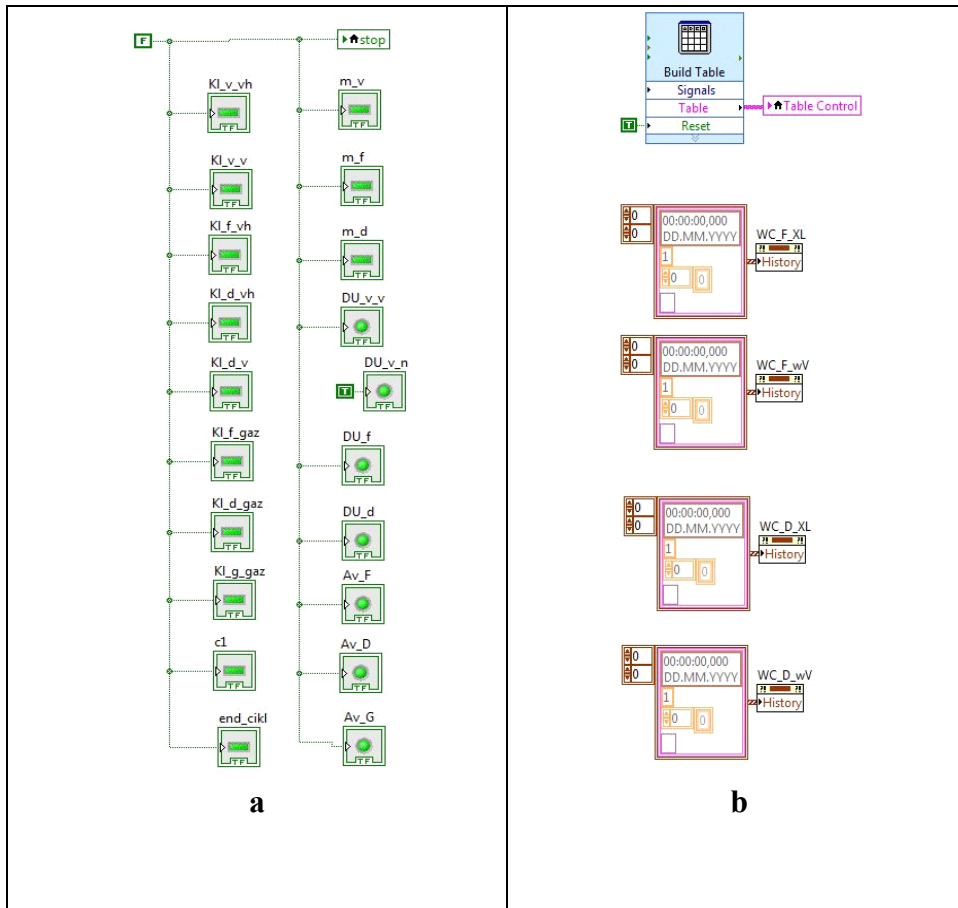
Fig. 2. Block diagrams of alternative energy sources working out processes development automation: a – initial indicators initialization; b – tables and graphs sweeping

Source: authors development

The interaction of users with applied software that is part of the system should be carried out using a visual graphic interface. The system must ensure the correct processing of emergencies caused by erroneous user actions, incorrect format or inadmissible input values.

To determine the order of execution of the program by organizing its elements in a certain sequence used open structure of the sequence Flat Sequance structure. This approach gives the following benefits:

– all frames of structure are visual and do not hide the sections of the code;

– data are transmitted to tunnels, not from local terminals.

In the first stage, the initial initialization of the indicators, the cleaning of the table and graphs, the concealment of intermediate variables and the tasks of other important parameters are performed.
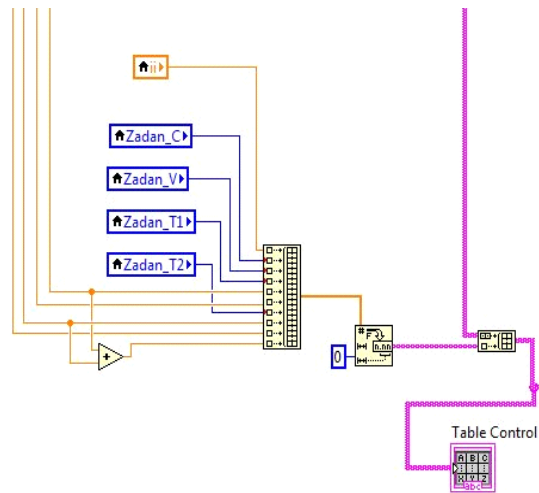
Fig. 3. Formation of the virtual complex data table: crushing effects: Zadan_T1 – tasks on the temperature of raw materials in the fermenter, ºC; Zadan_T2 – the task of the temperature of raw materials in the digester, ºC; Zadan_C – cycle time tasks, days; Zadan_V – the task of the volume of raw materials for processing, m³
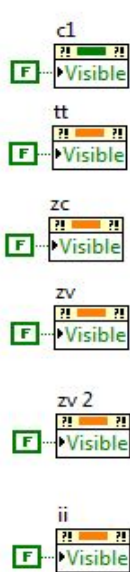
Source: authors development

Fig. 4. Hiding intermediate variables

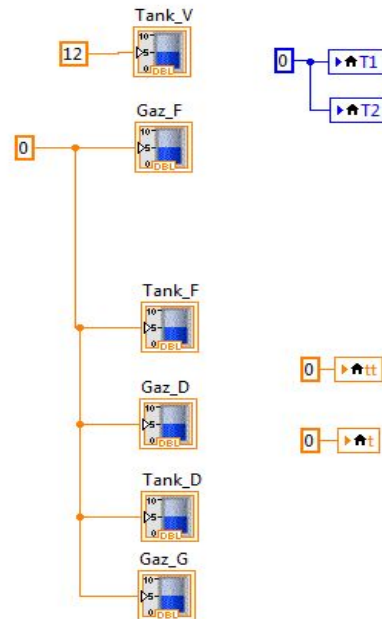*Source:* authors development

Fig. 5. Tasks of values of different parameters of substances

Source: authors development

As a result of the laboratory work with the use of a virtual laboratory complex as a result, the applicant receives the final result in the form of appropriate graphic dependencies.

At the preparatory stage of the laboratory work, the theoretical knowledge test concerning the object under study consists in a number of theoretical questions, to which answers are also offered. Choosing the correct answer, the student is credited with one point, while he is credited zero points for the incorrect ones.

As a result, the points are cumulated. Having 80 % of the correct answers to the questions, the student is allowed to work. Students with results less than 80 % are not admitted and have to take the theoretical knowledge test of the object under study again.

If the student answers 80 % of the questions correctly, the lecturer can look at the errors in the summary spreadsheet and ask these questions during the defense.

Taking into account all the mentioned above, the lecturer needs to do the following: prepare 8 to10 safety questions with proposed answers in advance, consider the questions to test knowledge concerning the purpose of work and possible answers, prepare questions and answer options to test the course of work knowledge and a number of questions (up to 10) to test students' theoretical knowledge of the system under study. Then the teacher enters these questions in the PC under his password and indicates the correct answer. This significantly reduces the time of checking admission to laboratory work, because the student without the lecturer's participation (either in his spare time or during a break) checks the readiness to perform laboratory work. The lecturer just needs to check the availability of the template for the report on this work.

Since laboratory works are performed on specialized equipment and their implementation algorithm is also special, then the methodological support should be specialized.

Guidelines for laboratory work on computerized diagnostic systems should consist of several separate manuals: a safety manual while working on a virtual diagnostic system, a manual on using software to verify admission to laboratory work and guidelines for performing particular laboratory work.

Guidelines for performing particular laboratory work should include the following sections:

– the topic of the laboratory work;

– the purpose of the laboratory work;

– theoretical provisions about the studied system and possible emergency modes –describing the emergency modes in the work itself, it is necessary to highlight what needs to be done in case of the bench failure;

– the work order;

– instructions for the work carrying out (according to the operational procedure);

– recommendations for the results processing;

– the report content;

– review questions (some additional tasks can also be added).

The Labview graphical environment can be used to optimize and increase the effectiveness of training sports, in particular, athletics. Therefore, the purpose of such application is:

– creation of the specified information structure, which will allow monitoring the stages of training, the amount and intensity of physical exertion;

– ensuring reliable, timely storage and access to the necessary information;

– formation of statistical data bases for training adjustments.

The use of Labview is particularly promising in rehabilitation systems for patients with diseases of the musculoskeletal system due to the consequences of severe injuries.

Modeling in the Labview graphical environment can be used both for

working with large amounts of statistical data and for processing relatively small amounts of data. The criteria for a sufficient amount of data can be considered both the research area and a specially developed analysis algorithm. It is also possible to identify non-trivial regularities.

Conclusion.

1. Laboratory work performed on computerized virtual laboratory complexes significantly reduces the execution time for each work, provided that the student is fully prepared to perform the work. To facilitate students' preparation for work, guidelines are created which include all the necessary material in full.

2. The process of checking admission to work is facilitated for the lecturer. If preferred by the lecturer, it is possible to conduct work defense on a personal computer, too. This will significantly reduce the time spent by the lecturer, but reduces the assessment adequacy, as there is a possibility for random guessing of answers to questions.

3. Therefore, the best solution is to carry out the checking admission to laboratory work on a computer, while defending it orally.

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