USE OF MODERN COMPUTER-BASED TRAINING RESOURCES IN ENERGY EDUCATION

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The author highlighted the rationale of implementing energy education into school teaching and extracurricular activities in Ukraine. A specific example demonstrates the opportunities of modern computer-based training resources use in the laboratory course of energy education. Digital measuring laboratories make it possible to carry out laboratory researches, which may not always be fulfilled using the conventional measuring instruments, due to the high rate of changes in physical quantities, which values must be fixed. The use of state-of-the-art applications, including those installed in digital measurement laboratories can significantly reduce the time for results processing, save results of experiments for further processing and information exchange between students. Posting the techniques of laboratory work on specialized Internet resources allows students prepare for laboratory researches in advance.

Key words: energetics, energy preservation, energy education, laboratory course, digital measuring laboratory.

Introduction

Energetics is a set of industries studying and using energy resources for the production, transformation, transmission and distribution of energy. Energetics is the basis for the development of economy, since it ensures technological processes and gives light and heat to the humankind. Ukraine as a state lacks own energy resources. Some types of fuel it produces cover only 20-30% of its needs, except for coal, the volume of production whereof covers 100% of its needs. At the same time, Ukraine has very energy-intensive economy. Over the past few years, Ukraine has been facing a severe energy crisis caused by accelerated development of energy intensive industries, free and wasteful use of energy resources, outdated technologies, depletion and degradation of explored deposits of coal, oil and gas, resulting in constant decrease in their production [Energetics, 2010]. Therefore, the problems of energy supply and preservation are extremely important for our country. An important component of the rational use of energy resources is the awareness of the population on energy and its conservation. Therefore, the introduction of a separate course of Energetics into the educational process in schools, extracurricular and higher education institutions becomes a pressing issue. Laboratory workshop is an important part of the educational process.

In laboratory researches, students are faced with the need to measure certain physical quantities, register obtained values in the test report, and construct respective graphs. Usually, the process of manual processing of experiment results takes much longer than the experiment itself. In addition, some processes that are subject to the study, are very quick, and the measured physical values change rapidly over time, which makes it impossible to fix them using conventional analogous or digital measuring devices. For this, computer-based learning tools, in particular, virtual and digital measuring laboratories and software for results processing are becoming more widely applied in laboratory settings. In addition, various Internet resources have become an important part of modern education.

Review of Related Literature

In the United States, energy education is being implemented, in particular through the National Energy Education Development Project [NEED, 2018]. Currently, the Junior Academy of Sciences of Ukraine (JASU) launched an all-Ukrainian project "New Energy Education" [JAS, 2015]. The National Center "JASU" works on the development of laboratory workshops for the "Energetics" course with the use of modern laboratory equipment and computer-based learning tools.

The development of digital information technologies has a significant impact on the further development of educational technologies, increases the role of extracurricular education, which in turn requires the elaboration of new curricula and knowledge assessment systems. In the United States, digital online repositories are being actively established for the storage and sharing scientific information during scientific and teaching activities [Brown et al., 2010]. Other authors highlight the feasibility of online video tutorials use by the students for preparation to laboratory research [Croker et al., 2010]. These video tutorials may greatly reduce the time required for laboratory practice and increase the effectiveness of training.

Online resource STEM-laboratory MANLab "Study through research", developed in Ukraine, allows educators to share own teaching materials and use those of other members [STEM, 2018]. Teaching materials posted on the site contain a list of equipment, theoretical information and description of laboratory research techniques. Where applicable, it is possible to post required video materials along with description of the procedure while characterizing the methodology of laboratory research. This resource can be used by students to prepare for laboratory practice.

The article by Anders Kluge demonstrates the feasibility of combining laboratory experiments with digital instruments for further processing, storage and sharing of research results among students [Kluge, 2014]. Thus, the usual photographing of intermediate and final results of laboratory experiment allowed the students to share their results and more deeply explore the processes that took place during the experiment. It is possible to study the processes in more detail now using results, including intermediate, saved in a digital form and further process these results upon completion of the experiment.

Many authors describe the possibilities opened up by video games and computer simulations in studying. According to the mentioned point of view, poor student achievements result from irregular quality of modern science education. The authors state that the use of digital simulation and serious educational games can increase motivation and interest to learning science and improve the understanding of scientific provisions under study.

The article by Sufen Chen presents the results of a pedagogical experiment, where two groups of students performed the same laboratory research using different methods [Chen et al., 2014]. The subject of the laboratory research was the study of Boyle-Mariotte law. The first group of students performed laboratory work using virtual means, in particular computer simulation, the second one – using a digital measuring laboratory with real physical objects. In both cases, the data collection and processing of results have been carried out using computer. Experiment demonstrated equally good results in both groups and significant progress in mastering the training material. However, the use of digital measuring laboratory including manipulations over real physical objects increased students' interest and motivation in studying the given phenomena. In particular, one of the students interviewed after the experiment said that during the laboratory practice in digital measuring laboratory he could feel the air pressure of a certain known value, and at this very moment he experienced a sharp increase in the interest in studying the topic of the laboratory work.

The opportunities provided by digital measurement laboratories for the educational process are discussed, in particular, in the work by Ihor Chernetsky [Chernetsky, 2012]. The digital measuring laboratory consists of primary converters, analogous and digital converter (ADC) and a personal computer [Chernetsky, 2012]. Primary converters are sensors of physical quantities: force, pressure, voltage, current, etc. The ADC can be available either independently or in combination with PC [Chernetsky, 2012] in the digital measurement laboratory.

The purpose of this article is to show, on a given example, the opportunities offered by the use of modern computer-oriented teaching resources in the laboratory workshop for the course of Energetics.

Presenting the Basic Material

Transformation of energy is an important part of Energetics course. One of the most common phenomena is the transformation of mechanical energy of rotational motion into the most convenient form − electric energy.

Energy is a scalar physical value, which is the only measure of various forms of motion and interaction of matter, the measure of the matter motion transformation. The unit of energy measurement is Joule (J).

The introduction of the notion of energy is convenient, since if the physical system is closed, its energy remains fixed throughout the time the system remains closed. This statement is called the law of conservation of energy, which is a fundamental physical law.

There are different types of energy: mechanical, thermodynamic, electrical, chemical, etc.

Mechanical energy, in its turn, may be potential and kinetic. The kinetic energy of a body is part of its aggregate energy, which is caused by the body movements. For translational motion, the kinetic energy is determined by the formula, J:

$$E_k = \frac{m \cdot v^2}{2} \quad , \qquad (1)$$

where **m** − mass of moving body, kg;
v − speed of motion m/sec.

Potential energy is a scalar physical value that characterizes the energy reserve of a body in a potential force field, which is spent on acquiring (changing) the kinetic energy of a body in such field.

The potential energy of a body located at a certain height in a gravitational field of the Earth, is determined by the formula:

$$E_n = m \cdot g \cdot h \quad , \qquad (2)$$

where **m** – body weight in the force field, kg;
g − acceleration of free fall, $g = 9.81$ m/sec^2;
h − height at which the body is raised, m.

If a body with weigh 1 kg is raised to 1 m, its energy reserve will be 9.81 J. If a body is released, its potential energy will decrease in proportion to the height, and kinetic energy will increase accordingly. Thus, the potential energy will transfer into kinetic one.

Mechanical energy may convert into electric with the use of induction electric machines – generators. Electric machines are usually reversible. That is, they can convert mechanical energy to electric and vice versa. The direct current motor is also a reversible electric machine. If the direct current motor is connected to a power source, its shaft will rotate and perform mechanical work. If you rotate the engine shaft, electrical voltage will appear on its terminals and it will become a source of electric energy.

The electric energy may be measured using the formula:

$$E_E = U \cdot I \cdot t \quad , \qquad (3)$$

where **U** − voltage, V;
I – current strength, A;
T – time, sec.

Thus, electric energy can be considered as an integral of electric power, P = U • I, according to time.

Each process of energy transformation is characterized by a coefficient of efficiency (efficiency factor), which is the ratio of primary energy to the received secondary. The efficiency factor is always less than one, since there act various losses, including friction, during the energy conversion process.

In this laboratory work it was proposed to investigate the process of transformation of potential energy of raised body into electric energy using direct current machine. The efficiency factor of this process is determined by the formula, %:

$$\eta = \frac{E_n}{E_E} \cdot 100\% \quad . \qquad (4)$$

For the performance of this laboratory work it is suggested to use the following equipment: “Electricity and Magnetism” PHYVE kit; magnetic board; loaded cargo; caprone thread; roulette; connecting cables; digital measuring laboratory consisting of the “NOVA” registrar, voltage and current sensors.

To perform the laboratory work it is necessary to make an experimental installation, which photo is shown in Figure 1.

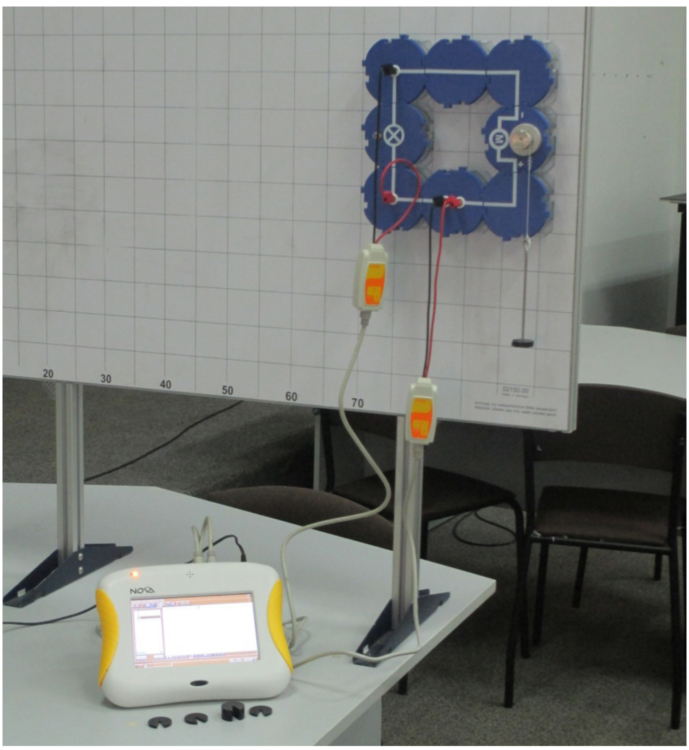

Figure 1. *Equipment for the study of the conversion of mechanical energy into electric one.*

Progress of experiment:

1. Assemble a circuit using "Electricity and Magnetism" PHYVE kit on a magnetic board according to Fig.1.
2. Connect voltage sensors to a circuit in parallel and current sensors – step-by-step.
3. Connect sensors to NOVA registrar.
4. Cut 1,5 m of caprone thread and attach it to the motor's outgoing pulley so that it can be reeled on and off.
5. Attach the combined load holder to the other end of the cord.
6. Measure the distance from the pulley to the end of the combined load carrier using the roulette and record it in the test report. This value will be the lifting height of load h.
7. Turn on NOVA registrar and make sure that the current and voltage sensors are automatically detected.
8. Adjust the registrar's settings:
9. Enter **"Registrar"** menu – **"Settings"**;
10. Select frequency − 10 measurements per second and **"Measurements"** − 500 measurements.
11. Reel on whole caprone cord on the motor's pulley.
12. Collect a load of 30 g and hold the pulley with your finger.
13. Click the **"Start"**  button on the registrar and make sure the data entry is started.
14. Release the motor's pulley and wait until the load is completely lowered.
15. Press the **"Stop"**  button.
16. Set the **first cursor**  on the obtained graph of current strength at the point where its growth begins.
17. Set the **second cursor** on the current strength graph at the point where the current terminates.
18. Enter **"Tools"** menu and perform **"Trim"** operation. As a result, graphs of current strength and voltage will be obtained within the time period during which the cord was unreeled under the influence of the load, and the engine pulley was rotated.
19. Enter **"Tools"** menu – **"Analysis"** – **"Analysis Master"** and select **"Product"** function.
20. As an multiplier factors, select the current strength and voltage, and press **"OK"**. As a result, a third graph will be obtained representing the dependence of electric power on time.
21. View the **"Tools"** menu – **"Analysis"** – **"Master Analysis"** and select the **"Integral"** function.
22. Choose the result of multiplying the current force and voltage as a function of integration, and press **"OK"**. A fourth graph of received electricity dependence on time will be obtained.

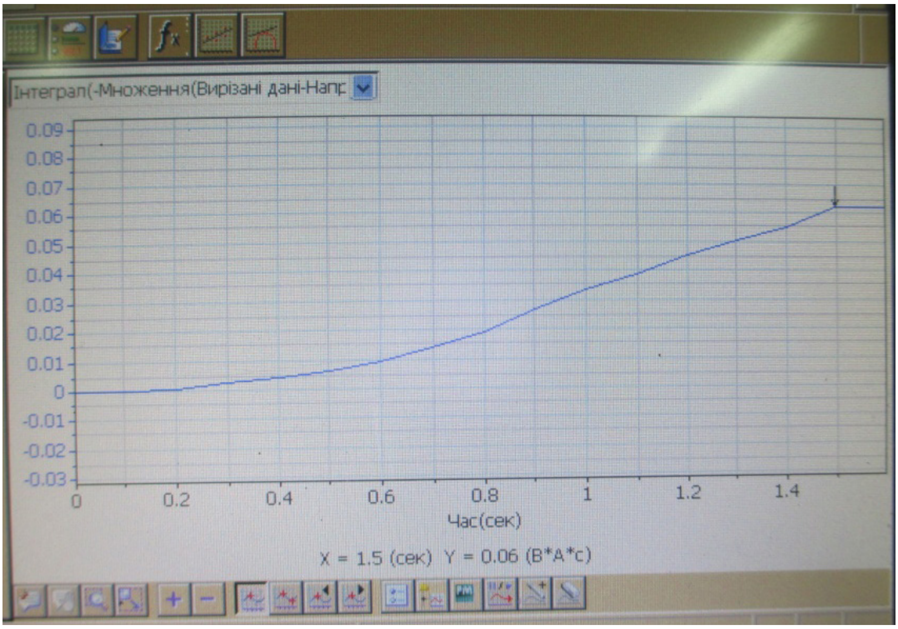

Figure 2. *An example of constructed graph of generated electric energy dependence on time and reading data therefrom.*

23. For convenience, hide three previous charts.
24. Set the cursor to the uppermost part of the obtained graph, take readings in V·A·c = J and enter it into the results table. This is the amount of energy generated.
25. Repeat the experiment according to items 9-22 with other combined loads up to 100 g.

To process the results of experiment, entered them in Table 1 and analyze.

h = ________ m

m, kg								
E_n, J.								
E_E , J.								
H ,%								

Table 1. *Experiment results*

To analyze the results of experiment it is necessary to calculate the potential energy of the raised load by formula (2) and the efficiency of transformation according by formula (3).

Without the use of digital measuring laboratory, the study of the transformation of potential energy to electric one would be practically impossible, as the process of load falling takes only 1-2 sec, during which the current strength and voltage vary. In addition, the use of digital measuring laboratory allowed a fairly quick mathematical processing of results of the experiment, in particular, the multiplication of the values and e integration of obtained dependence.

This laboratory work is posted on STEM-laboratory MANLab resource, which makes it possible to prepare in advance for its implementation [STEM, 2018]. The software used to process the results of laboratory work allows their saving, further processing and exchange between students.

Conclusions

Application of digital measuring laboratories in Energy education provides the opportunity to conduct laboratory works, which may not be carried out using conventional measuring instruments. The mathematical processing capabilities of digital measuring laboratories significantly shorten the time required for processing experimental results and, consequently, save the time of the educational process.

The option to store the results of laboratory work in digital form gives students the opportunity to work with them after completion of an experiment and share the data, thus extending their knowledge. Posting methods of conducting laboratory works on specialized Internet resources allows students to prepare in advance for their performance.

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