Application of digital technologies in higher education in "Materials Science" for transport complex

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Abstract. The article is devoted to the problem of digitalization of higher technical education in transport engineering and is aimed to improve the efficiency of independent work of students and improving the classroom work of the teacher with students through the visualization of lecture materials. The article presents a new electronic educational resource (EER) on the subject "Material Science", which is a multimedia textbook on the chapter "Theory of heat treatment" and "Practice of heat treatment" for visualization of complex hidden processes occurring in metals during heat treatment. Specific examples show how the usage of multimedia teaching methods in the educational process contributes to the visualization of invisible diffusion processes, which are accompanied by the formation of micro- and nano-sized structural components. The technology of open modular systems (OMS), used to create a software environment, its advantages and wider interactive possibilities in comparison with traditional software tools are described.

1. Introduction

Nowadays digital technologies are used in teaching various disciplines in higher and vocational education. The analysis of foreign and domestic experience of digitalization of education shows that the existing developments are mainly focused on the modernization of education and science through the creation of network services operating through the Internet. The application of interactive network resources is aimed on the solution of innovative scientific and technological problems, training of students and retraining of specialists through their interaction with remote software, multimedia and educational and scientific complex. In real time through the Internet technology, Workplace as a Service (WaaS), etc. are created conditions for remote access to the modern high-tech equipment, implementation of researches and experimental tasks, involvement of the student in the interested independent learning process. During the distance learning of students in natural Sciences, mainly the problem of remote access during laboratory and practical work on special equipment is solved [1,2].

There is no information about the application of digital technologies to describe the structure of materials and processes occurring in them. This is probably due to the fact that specialists in digital technologies do not have knowledges of material scientists, and, on the contrary, material scientists do not know how to use multimedia technologies to describe the hidden processes occurring in materials under the influence of various factors. Therefore, the creation of electronic educational resources (EER) in materials science is possible only with the direct interaction of programmers with material scientists.
The development of EER in materials Science is an urgent task of the modern educational process, as their application will significantly relieve the teacher and students, free up additional time for analysis of complex or specific moments, allows making a creative element in the process of studying the subject.

On the one hand, the development of an electronic educational resource (EER) is caused by the need to visualize the processes occurring in the metal during heating and cooling. On the other hand, the need to use multimedia materials is dictated by a number of factors that have been observed in the educational process in recent years. First, most students are very advanced users of computer technology and are willing to accept materials presented in electronic form. Secondly, students found, from their point of view, the easiest way to "study" the discipline – search for materials on the Internet; often they are not only poor quality, but also illiterate. The main objective of the proposed development is to increase the efficiency of independent work of students and improve the classroom work of the teacher with students through the visualization of lecture materials.

In higher technical schools imperative for engineering disciplines is "Material Science", which contains chapters on the science of metals and heat treatment of metals, which include basic concepts about the structure and properties of metals, methods of processing. Complex diffusion processes occurring in metals during heat treatment, plastic deformation, recrystallization, aging and other methods of exposure are accompanied by the formation of micro- and nano-sized structural components and are not visible to the unarmed eye. The description of these processes in textbooks or directly at the lecture does not solve the problem of assimilation of educational material by students, which creates an opinion about the complexity of the discipline.

In this regard, an urgent problem is the creation of a multimedia interactive electronic educational resource (EER) on the subject of "Material Science", corresponding to the educational standards of the Russian Federation for higher technical educational institutions.

The aim of this work is to develop an educational multimedia textbook on the chapters "Theory of heat treatment" and "Practice of heat treatment" for the visualization of invisible processes occurring in metals under thermal influence.

The work was carried out jointly by the departments of Technology of structural materials and Automated control systems MADI.

2. Methods of creating a multimedia textbook

In the development of the modules "Theory of heat treatment" and "Practice of heat treatment", the technologies of open modular systems (OMS) were used, which have wider interactive possibilities in comparison with traditional software tools, such as Adobe Flash [3, 4]. With its help, all sections and subsections of the topic are placed in one window, which greatly facilitates the search for any plot or fragment of the lecture.

On the basis of such multimedia technologies, it is possible to create electronic educational resources (EER) for educational materials containing images, texts accompanied by sound, video, animation and other visual effects.

The basis of the software environment is a modular architecture, in which each module is an independent content and functionally complete educational resource designed to solve a specific educational problem. In accordance with the principle of separation of programs and data software environment is separated from the content (content) modules [5, 6].

The main innovative features of the developed EER are [7]:

- provision of all components of the research process: obtaining information, practical training, modeling. For comparison, the book only transmits information;
- implementation of active forms of interaction with the content of EER, due to its high interactivity and multimedia.
- a significant increase in the capacity to improve self-study. The developed EER allows "at home", i.e. outside the classroom, to implement such activities that were previously possible only at the University (laboratory experiment, current knowledge control, and much more up to the collective educational work of remote users).
The main advantages of open modular systems (OMS) in comparison with traditional software tools are [7]:

- no technical limitations, it is possible to use and distribute interactive, multimedia in global computer networks;
- unlimited system life cycle. CHI is a dynamically expanding resource that does not require significant improvement when changing the content or technical external conditions.

In addition to the positive qualities of OMS can be attributed:

- ability to distribute on local media. Selected e-learning materials from the OMS together with the software can be easily transferred to a CD, flash drive, etc.

### 3. Results and Discussion

The chapter "Theory of heat treatment" discusses the processes, that describe the phase transformations in steels during heat treatment and most requires the development of video or animation visualization techniques, as the processes occur in motion in nano-sized level. By moving the cursor on the thermometer, independently varying the temperature, the student can observe structural changes in the steels that occur during heating or cooling.

The module "Theory of heat treatment" on the topic "Diagram of the isothermal decay of austenite" provides a virtual laboratory work in which the student, using text prompts, independently heats the samples, cools them in isothermal furnaces and in water, then measures the hardness, draws graphs, determines the time of the beginning and end of the decay of austenite and then builds a diagram of the isothermal decay of austenite.

![Figure 1. Visualization of the pearlite transformation.](image-url)
In the subsection describing the transformation of austenite under slow cooling, the process of austenite decomposition into a ferrite-cementite mixture of plate structure is visualized. The mechanism of perlite transformation, consisting in the diffusion of carbon atoms to the grain boundaries of austenite, the formation of cementite particles, their growth deep into the grain and polymorphic transformation of austenite into ferrite is shown in dynamics (Figure 1).

In the subsection describing the martensitic transformation, it is shown how, with rapid cooling, austenite instantly acquires a needle structure. Structural changes occurring during vacation are also shown. At the same time on the left in the window you can read the text of the lecture material with a description of what is happening on the screen.

4. Conclusion
Traditionally the laboratory furnaces and a hardness tester are used in educational process in laboratory work. Technically, laboratory work is difficult, and in a real educational process for its full implementation is usually not enough time. In addition, in classical textbooks on materials science its description is absent. Therefore, the virtual laboratory work is the only method to acquaint students with the method of constructing a diagram of the isothermal decay of austenite. In the process of laboratory work the student chooses an isothermal furnace, conducts heating, cooling, cleaning of samples, measures their hardness, draws graphs and concludes on the structure and properties of steel (Figure 2).

In laboratory work on the topic "Practice of heat treatment" research method is used, in which a student independently conducts technological operations of heating and cooling of samples, measures their hardness after heat treatment, draws graphs and based on the measurements makes conclusions about the effect of a type of heat treatment on the structure and properties of metals and alloys.

Figure 2. Virtual laboratory work “Diagram of isothermal decay of austenite”.

Thus, the developed electronic educational resource that allows visualizing the complex hidden processes occurring in metals during heat treatment, increases the efficiency of a teacher during lectures, laboratory work, and facilitates the assimilation of the material by students during independent work on the discipline "Materials Science".

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