Formation of Knowledge About the Basics of Hydromechanical and Thermal Processes Through Immersive Technology

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Keywords: E-learning, LMS Moodle, Virtual reality, Hydro-mechanical and thermal processes, virtual tour, 3DVista Virtual Tour Pro, Technology for creating a digital prototype of industrial production, Digital transformation.

Abstract: The paper considers the application of virtual reality technology in studying the basics of hydromechanical and thermal processes. Creation of educational VR content is based on the use of 3D Vista Virtual Tour Pro software package for the development of virtual tours. It allows to organize the learning process using innovative forms of training sessions that develop students' skills of teamwork, interpersonal communication, decision-making and leadership qualities through interactive lectures and group discussions, as well as to test the obtained knowledge by the means of quests. Quest results are transferred to the LMS Moodle system used to manage the educational process. The authors tested 2 groups of students of 10 people in each group, who study the course "Processes and apparatuses for environmental protection" with immersion into thematic virtual space (group 1) and without it (group 2). The test results showed a 29% higher proportion of correct answers for the first group, which confirms the expediency of using an immersive educational environment to improve the effectiveness of learning.

1 INTRODUCTION

At present, learning using Virtual Reality (VR) and Augmented Reality (AR) technologies is becoming increasingly relevant (Choi, S., Jung, K., Noh, S. Do., 2015; Nemtinov, V.A., Borisenko, A.B., Morozov, V.V., Nemtinova, Yu.V., 2021; Duda, J., Oleszek, S., 2020; Sheinbaum, V.S., 2017).

Creation of educational VR content is based on the use of 3D Vista Virtual Tour Pro software package for the development of virtual tours (3DVista, 2022; 3DVista, 2020). Since 2020, a large number of functions related to e-learning have been added to this software product including creation of quizzes and tests with evaluation of results, as well as integration with LMSs. This made it possible to use virtual tours in the form of 360° panoramas as a basis for exciting, interactive and realistic learning (Gallegos, C. et al., 2017; Nemtinov, V., Egorov, S., Borisenko, A., Morozov, V., Nemtinova, Yu., 2022; Lam, J.T. et al., 2019). A variety of software environments can be used to develop virtual tours with VR content (Epic Games, 2022; Lämkull, D., Zdrodowski, M., 2020; Nemtinov, V.A., Gorelov, A.A., Nemtinova, Yu.V., Borisenko, A.B., 2016).

The main functions of the LMS include creation and placement of educational content in various formats, including video tutorials, lectures, presentations, etc.; registration of students; differentiation of access to educational materials;

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control of the learning process using the chronology of trainees' actions and check the completion of tasks; ensuring communication of participants in the learning process; evaluation of the effectiveness of training, etc. (Yarramreddy, A., Gromkowski, P., Baggili, I., 2018;

Among the most popular LMSs, we can single out Moodle – a modular object-oriented dynamic learning environment. First of all, Moodle is an open-source server solution, but there is also a cloud service - Moodle Cloud [http://moodlecloud.com]. Many schools and universities have developed a large number of courses using Moodle, and in the paper (Wu, L. et al., 2020) the authors present the solution to the problem of integrating VR content with this platform. In this regard, this paper examines the issues of using the 3D Vista Virtual Tour Pro software in the educational process when training specialists in chemical technology.

Virtual tours allow students to move between panoramic photo and video materials. An important feature of 3DVista are tours with a live guide – a communication tool built into them. Live guided tours are available on desktop and mobile devices. The lecturer of the course under study can point out areas of interest in real time and discuss what is visible in spherical mode (360°) in real time. At the same time, a student can follow the teacher, look around independently or ask for permission to conduct the class, as if he/she were a teacher. This is well suited for asking questions about the elements and details of the technological process being studied or the equipment used for its implementation (Pozdneev, B. et al., 2019; Nemtinov, V., Zazulya, A., Kapustin, V., Nemtinova, Yu., 2019; Hidayah, N.A., Subiyakto, A., Setyaningsih, F., 2019).

2 CREATION OF A VIRTUAL LABORATORY SPACE FOR HYDRODYNAMIC AND THERMAL PROCESSES

Let's consider the issues of building a virtual space of the laboratory of hydrodynamic and thermal processes, which is a part of the Department of "Technological Processes, Apparatuses and Technosphere safety" of Tambov State Technical University, located on the website: https://heritage.tstu.ru/memorial/directaccess/korpus_l/index.htm .

Fig.1 shows a general view of the laboratory for studying hydromechanical and thermal processes, Fig. 2 – Fig. 4 show fragments of virtual space with various apparatuses.

To study the process of suspension filtration an apparatus shown in Fig.5 is used. The apparatus consists of a filter press 1, a piston pump 2, a suspension tank 3 with a bubbler 4, a compressor 5, a filtrate collection device 6 and a pressure gauge 14. The frame filter press consists of alternating rectangular frames 7 and plates 8, between which a filter cloth 9 is clamped. Every two adjacent plates with a frame between them form a self-working filter chamber. The plates of the frame filter press are equipped with drainage channels to drain the filtrate into the collection channels 10. The holes in the plates and frames coinciding along the axis form one common channel 11 for supplying the suspension to the chambers, 12 - for supplying the washing liquid and 13 - for compressed air for purging the sediment. The filtrate flows through the taps at the bottom of the plates.

Figure 1: Visualization of the general view of hydromechanical and thermal processes laboratory.

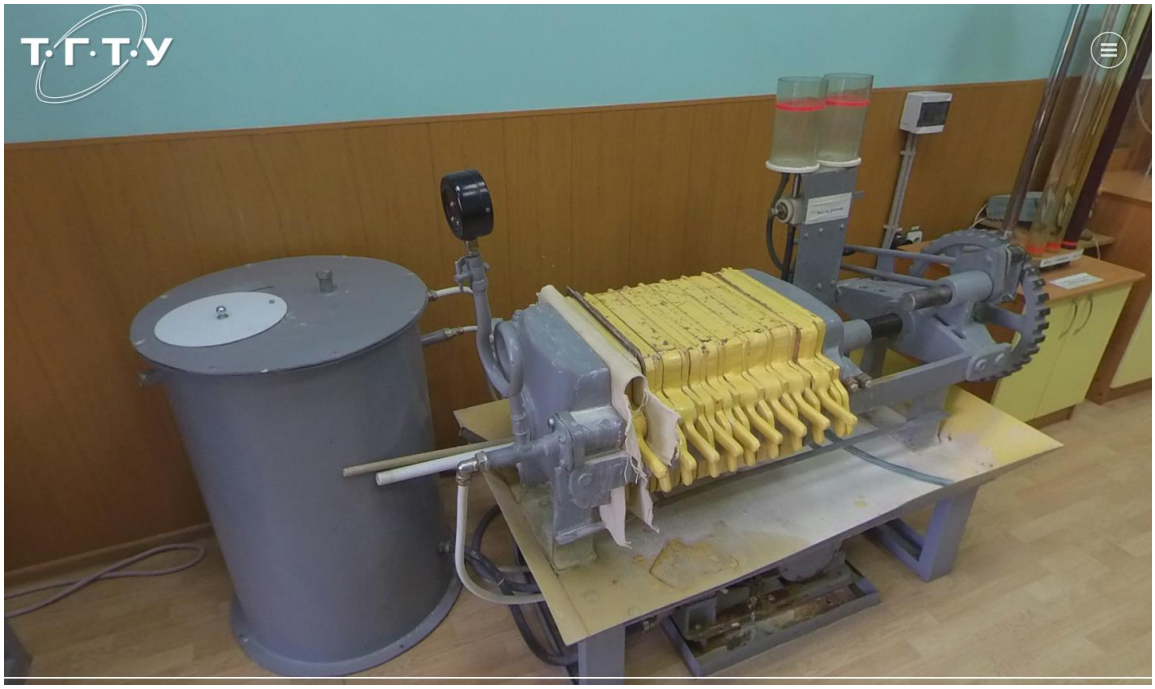

Figure 2: Visualization of the laboratory's fragment with a suspension filtration unit.

Figure 3: Visualization of the laboratory's fragment with an apparatus for studying vapor compression refrigerating machine

Figure 4: Visualization of the laboratory with an apparatus for studying thermal processes.

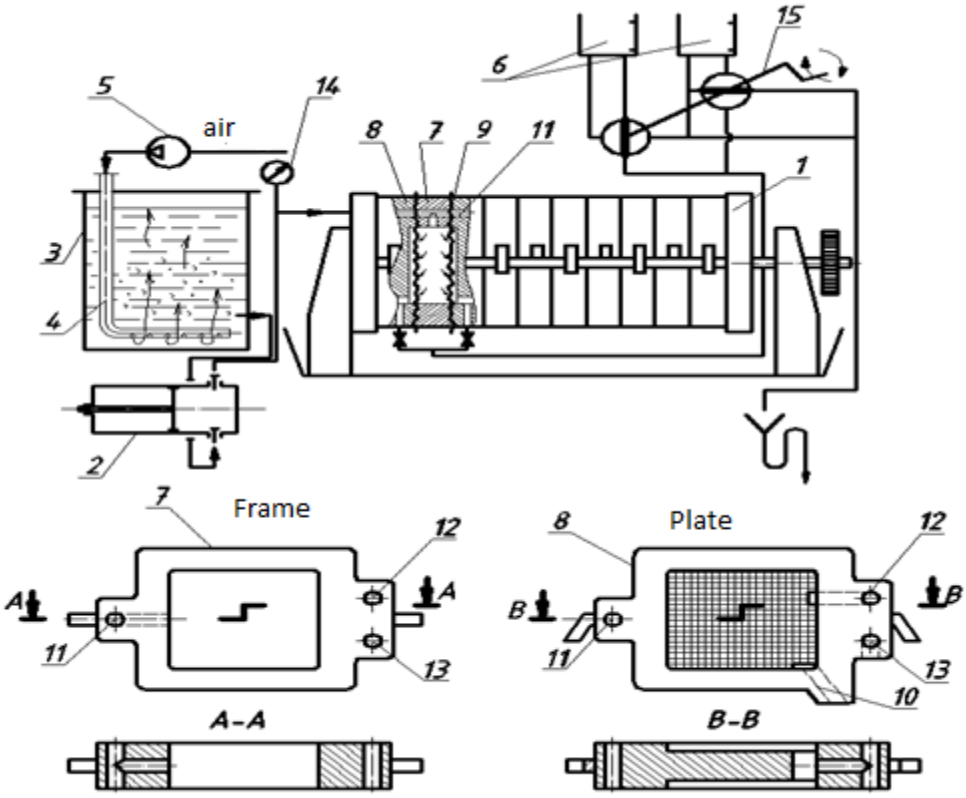

Figure 5: Suspension filtration scheme.

4 OBTAINING KNOWLEDGE ABOUT THE BASICS OF HYDROMECHANICAL AND THERMAL PROCESSES

After conducting a class in 3D Vista Virtual Tour Pro software environment in the mode with a live guide (teacher), students are given an opportunity to test their knowledge by answering a number of questions in the form of a quest (Tsarapkina, Y.M., Yakubova, E.Y., 2018; Zakirova, F.M., Qarshieva, D.U., 2020; Filatova, M.N., Sheinbaum, V.S., Shchedrovitsky, P.G., 2018; Bolbakov, R.G., Tsvetkov, V.Y., 2017).

Table 1 and Table 2 show fragments of the questions database for testing knowledge during the study of hydromechanical and thermal processes (the correct answers are highlighted in bold).

The results of the quest are transferred to the LMS Moodle, which is used to manage the educational process.

The authors tested 2 groups of students of 10 people in each group who study the course "Processes and apparatuses for environmental protection" with immersion into a thematic virtual space (group 1) and without it (group 2). The test results showed a 29% higher proportion of correct answers to the questions of the proposed tests for the first group, which confirms the expediency of using an immersive educational environment to improve the effectiveness of learning.

5 CONCLUSIONS

As a result of the research conducted by the authors, the electronic educational environment was created. It implements various forms of educational communication, provides necessary conditions for improving the quality of education, including such forms of group interaction as exchange of opinions and mutual consultation, which develop communication skills and ensure better mastering of

new academic material, which in turn increases the level of applied competencies and students' skills.

When using the proposed educational content, the educational process is carried out using innovative forms of training sessions that develop students' teamwork skills, decision-making, leadership qualities through interactive lectures and group discussions.

Table 1: A fragment of the questions database for testing knowledge of hydromechanical processes.

Questions	Response options	The number of points for the correct answer	Maximum response time (min.), ∞ - no restrictions
What type does this filter press belong to?	Chamber Filter Press	10	2
	Frame Filter Press		
	Membrane Filter Press		
How often does the filter cloth in the filter press needs to be changed?	**1-2 times a year**	10	2
	3-4 times a year		
	Once a month		
Frame filter presses are used …	**For fine filtration of suspensions with a low solid content**	10	∞
	For the separation of medium and hard-to-filter suspensions, when it is required to obtain a sediment with low humidity		
	To speed up the process of filtration of suspensions, as well as for processes where additional washing is required		
How is the filter press blown?	Argon	10	2
	Compressed air		
	Water		
What products do filter presses work on?	Coal concentrates	10	2
	Engine oils		
	Slimy products		
…	**…**	**…**	**…**

Table 2: A fragment of the questions database for testing knowledge of thermal processes.

Questions	Response options	The number of points for the correct answer	Maximum response time (min.), ∞ - no restrictions
Which of the above is not a refrigerant?	**Water**	10	1
	Carbon dioxide		
	Ammonia		
What is the upper cycle temperature of steam compression refrigeration units?	-20°C	10	2
	Ambient temperature		
	0°C		
What kind of refrigerant is used in this refrigeration steam compression unit?	Ammonia	10	1
	Freon		
Artificial refrigerants include	Fluorine	10	1

Questions	Response options	The number of points for the correct answer	Maximum response time (min.), ∞ - no restrictions
	Chlorine		
	Chladone		
What are the main elements of a refrigeration machine?	Evaporator, condenser, expansion cylinder	10	∞
	Evaporator, heat exchanger, generator		
	Compressor, evaporator, condenser		
…	**…**	**…**	**…**

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