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Student's knowledge checking at studying "Technical thermodynamics and heat exchange" discipline

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Abstract: *The discipline "Technical thermodynamics and heat exchange" provides ONMU students of ship mechanical speciality with knowledge, which are necessary for studying profiling special disciplines, such as: internal combustion engines, steam and gas turbines, steam boilers, refrigeration plants. Due to this course the students delve deeply into the essence of thermodynamic processes, which are taking place in ships machines and apparatus. They learn to work with tables and diagrams of thermophysical properties of substances. The main types of heat exchange are also considered applied to ship energetic plants in bodies of different shape in various states of aggregation. This discipline defines the quality of ship engineers training, so the diagnostics of knowledge gained by the students is the important part of the studying process.*

Key Word*: Discipline, Students, Ideal and real gas, Heat exchange, Lectures, Individual home task, Laboratory work, Multi-level control, Base knowledge.*

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I. Introduction

For the convenience of studying of this rather voluminous material, the discipline "Technical thermodynamic and heat exchange" is divided into three parts (modules). In the limits of these modules the processes and cycles in ideal and real gas and heat exchange basics are consistently consider.

There are the most popular textbooks on this discipline [1-5]. In addition to them we also published the study guides [6-8]. Theoretical material on all three modules along with the questions for self-control and task solutions examples are given in these guides.

II. The Teaching of the Discipline "Technical Thermodynamics and heat exchange" and Ways of Students' Knowledge Diagnostics

The working program of studying the discipline is built in such way, that in the limits of the first module the students are studying the thermodynamic processes and cycles that take place in ideal gas. Within the limits of second module – processes and cycles in real gas are shown. The third unit is devoted to the features and peculiarities of different types of heat exchange. Material of each unit is presented in the appropriate study guide.

In "Thermodynamic processes and cycles in ideal gas" guide the concepts of equation of state, thermodynamic processes; work and heat of processes are given. Also the first and the second laws of thermodynamics are stipulated here. The first law is formulated for static bodies and for stationary flow. As to the second law, its main formulations and description of the experiments which prove their justice are given in the guide. The processes and cycles in ideal gas are investigated on the basis of first and second lows. The cycles of internal combustion engines along with gas turbines cycles are shown here, and the methodologies of calculating of their energetic indicators and assessment of their efficiency are also given in it. The home task and the test work to the first unit are dedicated to calculating the mentioned cycles.

In the guide "Thermodynamic processes and cycles in real gas" presents the features of thermodynamic behaviour of real gas, which are the working bodies of steam turbines and refrigerating plants. A lot of attention is paid to tables of thermodynamic properties of substances and to diagrams of state. Thermodynamic processes in real gases are analyzed, too. The ways of calculating main varieties of cycles of steam turbine plants are described in details. The influence of feed water regenerative heating and intermediate overheating of the vapour to the efficiency of these cycles is shown. Also the specifics of processes in refrigerating plants and in wet air are stated. At the end of second unit the students carry out the home task and the test work on calculating steam turbine plant cycle.

The third guide is aimed on the study of heat exchange processes in liquids and gases, including processes of boiling and condensing, and also the calculating of heat exchange apparatus. In the guide the main ways of elementary and complex heat exchange for bodies and surfaces (which are the most characteristic for ship energetic plants) are described in details in the guide. We should also consider the time factor while describing of the processes of heat exchange in contrast to the thermodynamic tasks. Studying the material of the module the students carry out home task and the test work on the heat exchange processes calculation.

In present time the fundamental textbook [9], which combines the material from three study guides is going out of print. The textbook contains also the scientific sections devoted to improving the energetic plants cycles. These sections must stimulate the creative approach to engineering work for teachers and students.

The important elements of teaching are:

- Completeness and quality of material presentation;
- Consolidation of theoretical knowledge on practice and in laboratory classes;
- Presence of the textbooks and the methodical guides;
- Objectivity of the students' knowledge evaluation.

The lectures on the discipline are given using the multimedia equipment. The text of the lectures, formulas and pictures are presented on the screen. The students can compare the material that they see on the screen with the content in their guides, and just make the short notes in their conspectus. The full texts of the lectures both printing and electronic are available for the students. Students are recommended to study the appropriate material themselves by guides. This, in particular, will facilitate the successful passage of test control. Students' presentation in regional and international conferences contributes greatly to the deepening of their knowledge. For this they should prepare the reports under the supervision of the teachers.

The quality of assimilation of the theoretical material by the students is checked by means of computer testing at the end of each module. During the testing students are set down at the separate computers. Each of them has own log-in and password. After entering the system a student is offered to answer fifty questions which are chosen by the computer from two hundred ones that are in the database on each module. The student must choose the most correct answer from four or five appearing on screen. Students get limited time for answering the questions, which doesn't allow using the guides during the check-up. Students must answer all questions. If the student skips or misses an answer, the program interprets it as an incorrect answer. On the figure no 1 we can see a screenshot of working program for checking the students.

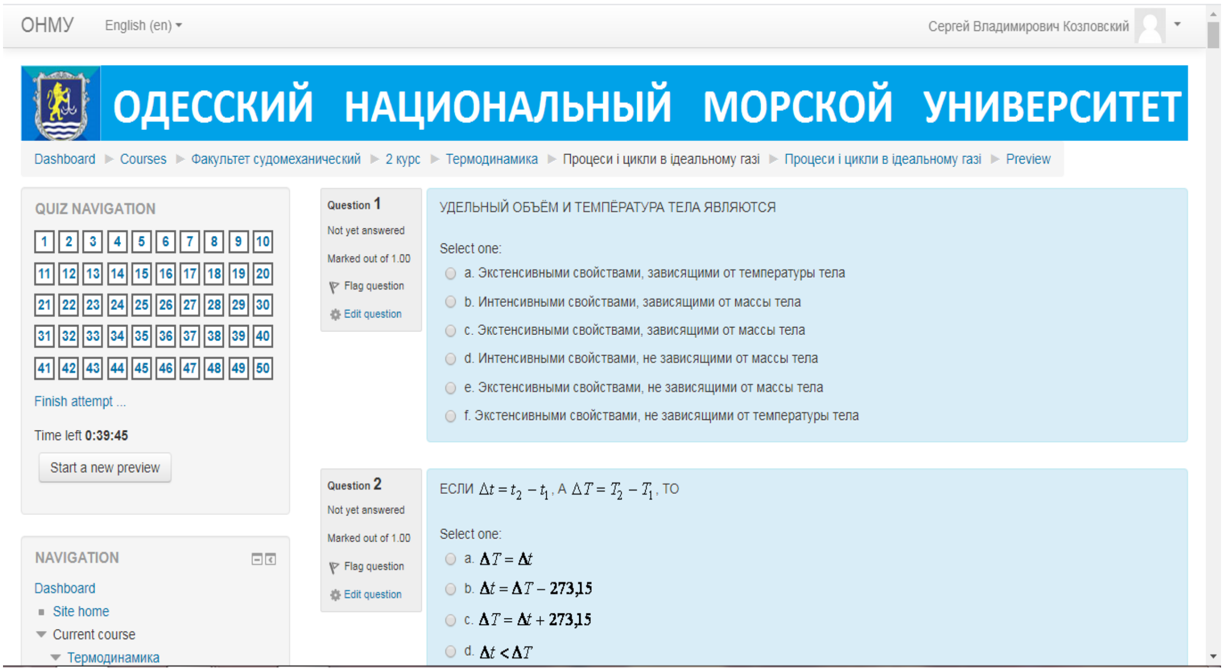

Fig. no 1: Screenshot of working program for checking the students

Theoretical knowledge received by the students is fixed while carrying out tasks at practical classes. During these classes students learn to work with tables and diagrams of thermophysical properties, calculate thermodynamic processes in ideal and real gases, cycles of internal combustion engines, steam turbine and gas turbine plants, and also they calculate heat exchange processes in the mentioned machinery.

In the first module tasks we set initial values for some working fluid thermodynamic parameters in the cycle, or the values of energetic effects. A student must determine all missing values of parameters, cycle characteristics, energetic effects and must evaluate the cycle efficiency by means of ratios for ideal gas, known from the lectures. For individual home work a student calculates Trinkler cycle with known five parameters of working body. The sample of this task form is given on figure no 2. After the student proves his individual task, he must carry out the test work on the first module, which is similar to his home work.

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HOMETASK №1
For the first module on discipline «Technical thermodynamic» student **2** course __ gr.

Given: Deadline:

Internal combustion engine is working at parameters pointed in the table. It is necessary to calculate the parameters which absent in the table. Draw the theoretic cycle of mentioned engine on the work and heat diagram.

Parameters designation and dimension		Parameters designation and dimension		Parameters designation and dimension	
ε		T_3, *K*		q_2, *kJ/kg*	
λ		p_4, *MPa*		$l_{1\text{-}2}$, *kJ/kg*	
ρ		T_4, *K*		$l_{4\text{-}5}$, *kJ/kg*	
p_1, *MPa*		v_4, m^3/kg		$l_{3\text{-}4}$, *kJ/kg*	
v_1, m^3/kg		p_5, *MPa*		Σl, *kJ/kg*	
t_1, *°C*		v_5, m^3/kg		Σq, *kJ/kg*	
p_2, *MPa*		T_5, *K*		η_t	
v_2, m^3/kg		q_{1v}, *kJ/kg*		$\eta_{t,\,k,\,eq.}$	
T_2, *K*		q_{1p}, *kJ/kg*		$\eta_{t,\,k,\,utmost}$	
p_3, *MPa*		q_1, *kJ/kg*		$H_{perfection}$	

Fig. no 2: Screenshot of working program for checking the students

In the second module tasks it is necessary to determine the parameters of water and water steam in characteristic points of steam turbine plant cycle and cycle energetic parameters. On the beginning stage, when the students are learning to work with tables and diagrams of thermophysical properties of water and water steam, they are calculating the Renkin cycle. Further students are completing the tasks for more complex schemes of steam turbine plants that realise the main ways of their efficiency increasing.

For individual home task on second module students perform the calculation of steam turbine plant thermodynamic cycle. Depending on the task option, the scheme includes the feed water regenerative heating or vapour intermediate overheating in steam turbine plant. The sample of an individual task form for the second module is presented on figure no 3. The initial data are: two initial parameters of vapour, vapour pressure in condenser and, depending upon the option, parameters of vapour intermediate overheating or vapour parameters at extraction and regenerative heater type. As at first module, after this task being proved a student performs the test work of the same type.

The tasks of the third unit include the calculation of heat exchange processes. In these processes the heat exchange may be both elementary (thermal conductivity, heat rejection, radiant heat transfer), and complex, which combines some elementary ways. In some tasks there are two ways of heat exchange: at substance aggregate state change (boiling and condensing) and through the complex (ribbed) walls. The sample of individual task form (test work) on the third module is given on figure no 4.

In order to fix theoretical knowledge, we must keep in mind the importance of laboratory works as well as practical tasks solution. So, six laboratory works are foreseen by the work program on the discipline, two works for each module.

In the first laboratory work of the first module the students measure parameters to calculate constant air volume at different pressures in the isothermal system. In the course of the second work students define isobaric air heat capacity. In this work the air is heated while passing through the calorimeter. After accuracy estimation of received results students will prove their protocols to the teacher.

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HOMETASK №2
For the second module on discipline «Technical thermodynamic» student **2** course __ gr.

Given: Deadline:

Fulfill the calculation and the investigation of the steam turbine plant scheme, that is given by the following initial parameters in the table. It is need to calculate:

- Parameters of the vapor in all characteristic points of the processes which make of the cycle of steam turbine plant;
- Specific theoretical heat, vapor and fuel consumptions in mentioned cycle of steam turbine plant;
- Efficiency of mentioned cycle of steam turbine plant in compare with Renkin cycle and boundary Karno cycle;
- Draw the principal scheme and cycle of steam turbine plant in p,v; h,s; T,s coordinates.

Parameters	Dimension	Designation	Parameters	Dimension	Designation
Initial parameters of vapor			Parameters of vapor intermediate overheating		
pressure	*MPa*		pressure	*MPa*	
temperature	*°C*		temperature	*°C*	
entropy	*kJ/(kg·K)*		Vapor pressure at extraction		
enthalpy	*kJ/kg*		pressure	*MPa*	
Parameters of vapor in condenser			The type of regenerative heater		
pressure	*MPa*				

Fig. no 3: The sample of the individual home task for the second module

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HOMETASK №3
For the third module on discipline «Technical thermodynamic and heat exchange»

student **2** course __ gr.

Given: Deadline

Perform the next tasks:

1. Steam line with the diameters 160/170 mm is covered with double layer insulation. Thickness of the first layer is δ_2 = 30 mm and for the second is δ_3 = 50 mm. The coefficients of the pipe and insulation heat transfer are respectively equaled $\lambda_1 = 50$, $\lambda_2 = 0{,}15$ and $\lambda_3 = 0{,}08$ Wt/(m·K). Temperature of the steam line internal surface is t_1 = 300 °C and insulation external surface is t_4 = 300 °C. It is need to define the heat flux density and temperatures on the interfaces of the individual layers.
2. The smooth surface with width of b = 1 m and length l = 1,2 m is blown with an air with speed of ω_0 = 8 m/s. It is need to define the average coefficient of heat exchange $\bar{\alpha}$ and full heat flow Q. The temperature of the surface is t_c = 60 °C and the temperature of the air is t_a = 20 °C.
3. It is need to define a heat loss by radiation from steel pipe surface with the diameter of d = 70 mm and the long of l = 3 m at the surface temperature of t_1 = 227 °C. The pipe is : a) in big brick premise with the walls temperature of t_2 = 27 °C; b) in brick channel with the square of 0,3X0,3 m^2 at the walls temperature t_2 = 27 °C.

Fig. no 4: The sample of the individual home task for the third module

Laboratory works of the second module contain tasks, which let the students learn the thermodynamic behavior of real gases. In the first work students define experimentally the dependency of saturated vapor pressure curve (of substance under research) on its temperature. In the second work they calculate the indexes of water vaporization heat with the experimentally received parameters indexes included in the heat balance equation for the laboratory system. After protocols are issued and proved by the students, this work is considered complete.

During the third module students fulfils laboratory works on investigation the process of heat rejection at free convection. During the first work only convection heat exchange of the heated pipe with air is investigated when placing the pipe horizontally, vertically and at angle 45°. In the second work besides the convention component the heat exchange by radiation is also taken into account. Received values of heat rejection coefficient are compared with ones, calculated by empirical formula for the same conditions.

Final assessment of students' knowledge on every module is obtained by summing of the marks on every types of control. Maximal mark of hundred points is forming on such way: ten points – for classes entering, ten – for laboratory works, ten – for homework, thirty – for test work, and forty – for testing. The mark on discipline is calculated as arithmetical mean of the marks on each module. So, in the process of all tasks fulfilling the students are marked on every type of educational work. Multi-level control provides objectivity of students' knowledge assessment.

III. Conclusion

At studying the discipline "Technical thermodynamics and heat exchange" the students of speciality 271 "River and marine transport" receive base knowledge about thermodynamic processes, which occur in energetic and refrigerating plants. These knowledge is necessary for studying the major disciplines. Students' training includes: theoretical foundations of thermodynamic and heat exchange studying, practical tasks solution, and laboratory work fulfilling. At the end of each module the detail control of student' knowledge is carrying out, which includes laboratory works protocols defending, homework and task work checking, and testing on computer.

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