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# Computer-aided design and research of chambers of wood drying by means of SolidWorks API and COSMOSFloWorks

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*The thermal calculation and the analysis of physical steams in a forest drying chamber have been done using COSMOSFloWorks design information technologies. The system of SolidWorks 2011 computer-aided design has been used for the solid state modeling of a forest drying chamber and the creation of three-dimensional models of its components. On the basis of SolidWorks API the «Wood v.1.0» program-oriented complex has been developed and realized using the Microsoft Visual studio 2010 compiler which enables to research the chamber parameters, as well as control the geometry of the forest drying chamber and stack.*

**Key-words:** CAD, SolidWorks, SolidWorksAPI, SolidWorksSimulation, SolidWorksFlowSimulation (COSMOSFloWorks), model, forest drying chamber, drying process, temperature.

**Introduction.** Design information technologies are introduced into all the spheres of practical activities. They are a necessary tool for the design and creation of modern energy-saving technologies, in particular, in woodworking sphere — drying chambers for drying of wood and other capillary-porous materials. The usage of computer-aided design systems and the engineering analysis — CAD/CAE — systems (Computer Aided Engineering) is one of possible ways of physical processes computer simulation in wood drying chambers. In this respect, the program systems integrated into CAD (systems of computer-aided design) are of importance, as well as enable to research complex thermal-physical and aerodynamic processes in multicomponent anisotropic environments. The class of such systems includes COSMOSFloWorks [1] which is based on updated achievements of calculating methods and is integrated along with SolidWorks computer-aided system of geometric design.

That is why the search for efficient ways on the design of forest drying chambers is directly connected with the computer-aided design systems development on the basis of computer simulation and making of optimal design solutions.

## 1. The analysis of the research

The analysis of references [2-4] and practice of the forest drying chambers design testify that the research of forest drying chambers as the objects of the design and their computer simulation require further substantial improvement. Available mathematical models of heat and mass exchangeable fields in forest drying chambers are based on material and thermal balances equations [2, 4] which determine changeable mass and heat flows of a coolant. On the basis of such an approach drying chambers computer simulation is realized mostly from the viewpoint of control systems [3]. It is necessary to indicate that computer models of the heat and mass exchange engineer analysis in forest drying chambers are quite rare. Due to engineer analysis technologies CAE (Computer Aided Engineering), the capabilities of the numerical analysis have widely extended in connection with the intensive development of computer engineering and software for recent years. In terms of CAE there is such a class of programs as CFD (Computational Fluid Dynamics) designed for the computer analysis of physical fields [5, 6]. Such programs as COSMOSFloWorks, Fluent, Flowvision and others belong to this class. CFD programs proved themselves as being good for scientific researches of heat and mass exchangeable fields in various branches of industry. In the research there are given the possibilities and expediency of the COSMOSFloWorks use in combination with SolidWorks for the drying chamber construction design, as well as the heat and mass exchangeable processes analysis in drying chambers.

Virtual laboratories [7] have expanded greatly, though most of them are built using Java or other similar technologies and do not use specialized software. In particular, they are not designed for the work with popular CAD/CAM/CAE systems such as SolidWorks.

It is vital to indicate such important capabilities of virtual mathematical laboratories as an interactive simulation, an experiment and parameters variation. The last capability enables to directly observe the change of a researched object and control this change. Two objectives are achieved with the help of this: 1) a high interactivity level of environment in which a researcher works; 2) in the background of gradual changes of an object there are revealed its inherent regularities.

Analyzing references, there appeared the task to create a peculiar virtual laboratory for the analysis of heat and mass exchangeable processes in drying chambers. For the sake of this, in terms of the given design a supplement was created on the basis of SolidWorks API (Application Programming Interface, API) and SolidWorks software package.

## 2. Setting the task

To design a three-dimensional geometric model of a sawn timber drying chamber by means of SolidWorks, COSMOSFloWorks, the interface SolidWorks API. To develop a program supplement for the control of chamber input parameters, results of conducted experiments, as well as three-dimensional model of forest drying chambers and the parameters change of the charging wood stack. In COSMOSFloWorks program medium to model the distribution of thermal fields in a chamber during the drying process of sawn timber. To research the distribution dependence of dried wood temperature and humidity, sawn timber imitation surfaces caused by different capacity degree and quantity of thermal radiators, air movement direction and speed in a chamber.

## 3. The analysis of the means SolidWorks API

The SolidWorks 2011 computer-aided design system has been used to create the three-dimensional forest drying chamber model. Its medium and tools are well adapted to the construction of complex surfaces and assemblages.

For the experimental model construction the chamber of periodic action has been selected. The most important chamber elements, e. g. radiators (Fig. 1*a*), ventilators (Fig. 1*b*) and air supply systems (Fig. 1*c*) have been designed. After the design completion the assemblage of the solid model consists of the following: the quantity of ventilators and radiators set by a user, the false ceiling, the stack on a substack cart (Fig. 2), the air supply system (Fig. 1), the very chamber and the chamber ceiling, as well as ventilation chokes (Fig. 3).

The created 3-D model of the forest drying chamber corresponds to sizes of real chambers the scale to be 1:1 what significantly slows down the process of the imitation modeling. In order to avoid the great loss of time on each experiment, the model of reduced sizes has been worked out.

Issues connected with the construction of specialized supplements, which provide the solution to applied scientific and engineering problems with the help of various

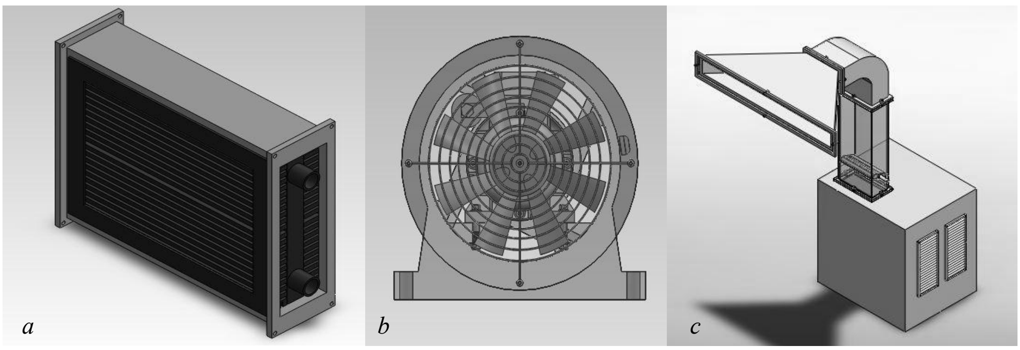


Fig. 1. Solid 3-D models of the chamber elements: *a* — radiator; *b* — ventilator; *c* — air supply system

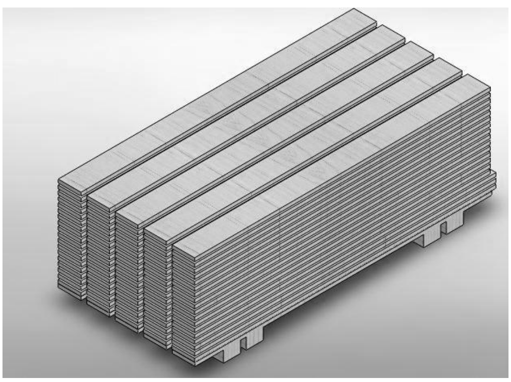

Fig. 2. 3-D stack model on a substack cart

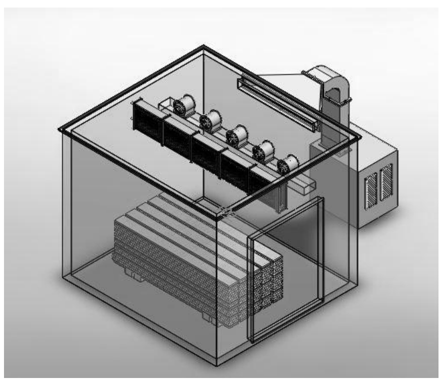

Fig. 3. Solid 3-D model of a forest drying chamber of periodic action in assemblage worked out by means of Solid Works

program supplements integration with the aim of unique information system (IS) creation, become of special topicality. The supplements integration is a more difficult task in comparison with the traditional data integration. However, the integration at a level of supplements possesses a list of indisputable advantages. They comprise, first of all the providing with the continuous cycle of supplements information interaction in terms of IS; computer-aided execution of service supplements according to the instruction of IS base components; high speed of operation caused by the absence of the necessity in interim data formats; minimization of disk operations etc. That is why, one of basic requirements brought forward for the components of updated information system is the possibility of the program control of the functional means set realized in these components.

In other words, the application programming interface (API) availability in this or that supplement is necessary and sufficient for the solution of the informational system components integration problem at a level of supplements.

SolidWorksAPI is an applied programming interface which enables to develop user programs at the platform of SolidWorks. API comprises hundreds of functions which are possible to invoked out of such programs as Microsoft Visual Basic, VBA (Microsoft Excel, Word, Access etc.), Microsoft Visual C, C++, C#, .NET or SolidWorks files-macros. API-functions provide direct program access to functional capabilities of SolidWorks packet.

It is revealed in practice that if the capabilities of an ordinary user interface are more than enough for the ware design in the CAD-system medium, than it is necessary to interconnect heterogeneous program products for the tasks solution of the supplements integration at a level of unique IC having rectified a full informational interaction between them. API is already indispensable here. Accordingly, the most important sphere of SolidWorks applied programming interface application is SolidWorks integration along with various Windows-supplements (CAD/CAM/CAE/PDM/ERP, MS Office, Windows API etc.) what assumes the interfaces creation of data transfer, service utility software call, data conversion, as well as applied modules development which are added to basic capabilities of SolidWorks additional functional in any special subject sphere, for instance, in a problem of forest drying chambers characteristics research.

Applied programming interface is presented in the composition of CAD SolidWorks base configuration. Except the base design solution API is included into all basic modules (Toolbox, FeatureWorks, Utilities, PhotoWorks, eDrawings, Routing, SWR-PDM, SWR-Electrics) forming a part of SolidWorks packet. Dynamic libraries of types and constants responsible for the API work are automatically installed onto a computer at the program installation. In such a way every CAD SolidWorks working place according to the default is equipped with applied programming interface which gives a wide range of possibilities to developers. In a reference system it is possible to find a detailed description of API structure, as well as a list of new functions added to API before the moment of updated SolidWorks description version appearance (Fig. 4). The reference is invoked out of «Reference sections on SolidWorks and API modules» menu. The reference system is expanded by a set of samples «SolidWorks API SDK» (Software Development Kit developer’s set) updated at the appearance of every new version of SolidWorks.

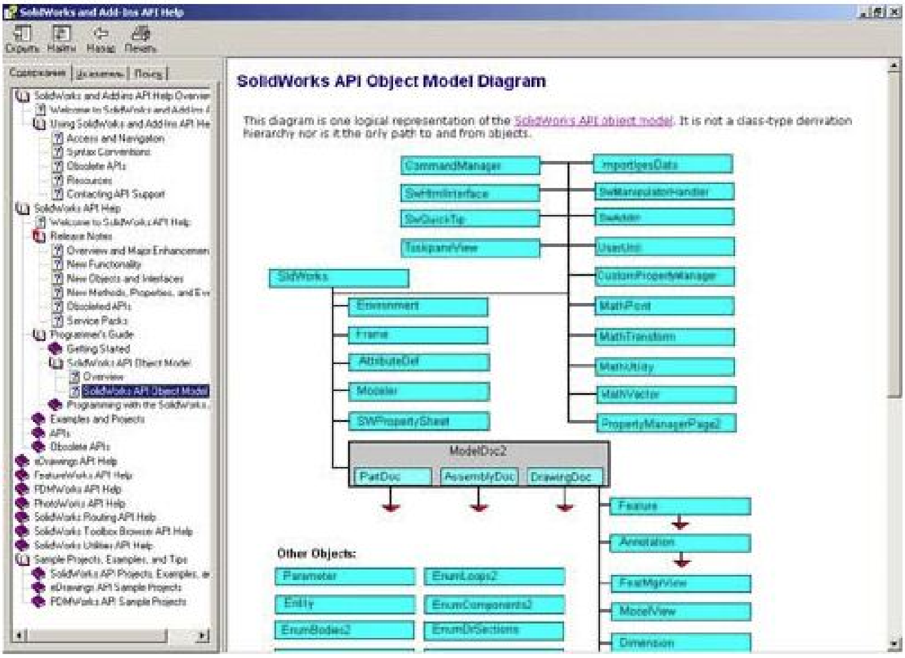


Fig. 4. The reference system SolidWorks API

## 4. The development of the program supplement Wood v1.0

It is essential to have an access to SolidWorks API out of Microsoft Visual Studio 2010 for the development of the program supplement Wood v1.0. Therefore, there is a necessity to set corresponding libraries which can be downloaded from the official site of Solid Works. Thereafter, it is possible to use two ways of the supplement creation on C#:

- the use of SwCSharpAddin which contains templates for the supplement construction (Fig. 5);
- recording and adjustment of macros which is the most widespread and researched.

Further work consists in the macro correctness and succession of the contact with the objects of SolidWorks (Fig. 6).

The succession of contacts with the objects of SolidWorks, in particular their invoking and variation, will be understandable for a compiler (certainly, if all the libraries and namespaces for these objects are installed and connected). Having made all the adjustments, it is possible to control a created program as an independent supplement which is developed according to the set task and will add an additional functionality to basic capabilities of Solid Works. Both graphic and tabular reflection of results has been used for outputting and preservation of modeling results, and the data preservation is accompanied by the corresponding XML file.

The next step is running of the program Solid Works and the activation of the supplement SolidWorks Simulation. Thereafter, it is necessary to open the assemblage

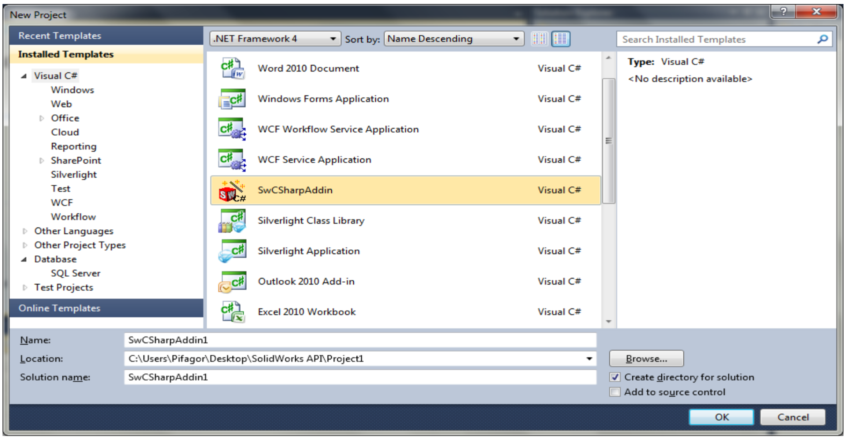


Fig. 5. The template for the supplement development
which will be reflected as a separate toolbar in SolidWorks

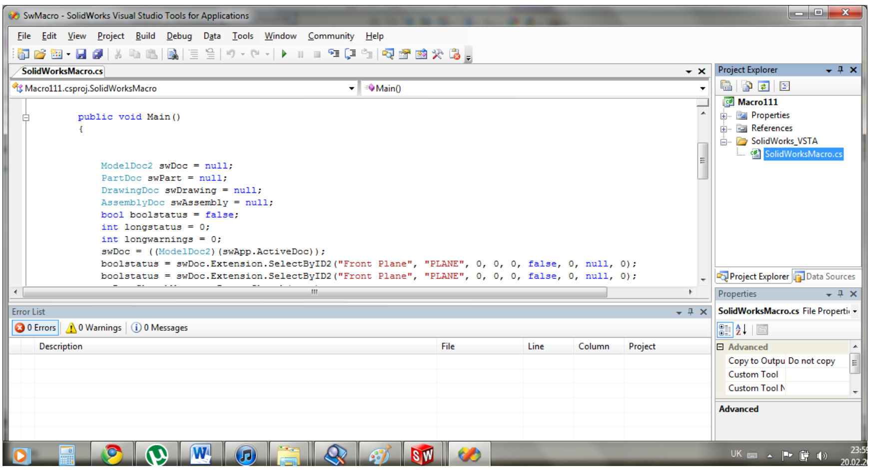


Fig. 6. Editing of the macro in the program medium Microsoft Visual Studio 2010

which contains a designed 3-D model of the forest drying chamber and then run Wood.exe. The model of the chamber and the applied program are located in the root directory of the design.

Every model is a separate informational core. The model has a convenient graphical interface with different controlling elements with the help of which a user may change parameters what permits to analyze its behaviors under different conditions. During the activation of the program a screensaver which collects necessary resources for further work of the program appears (Fig. 7).

With the help of the interface inset «Geometric parameters of forest drying chambers» (Fig. 8) a user may set geometric sizes of the chamber, as well as indicate the quantity of ventilators, radiators and increase the quantity of boards in a stack.


Fig. 7. The interface
of the supplement Wood v1.0

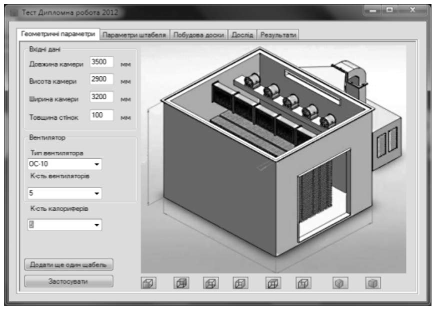


Fig. 8. The interface inset «Geometric
parameters of forest drying chambers»

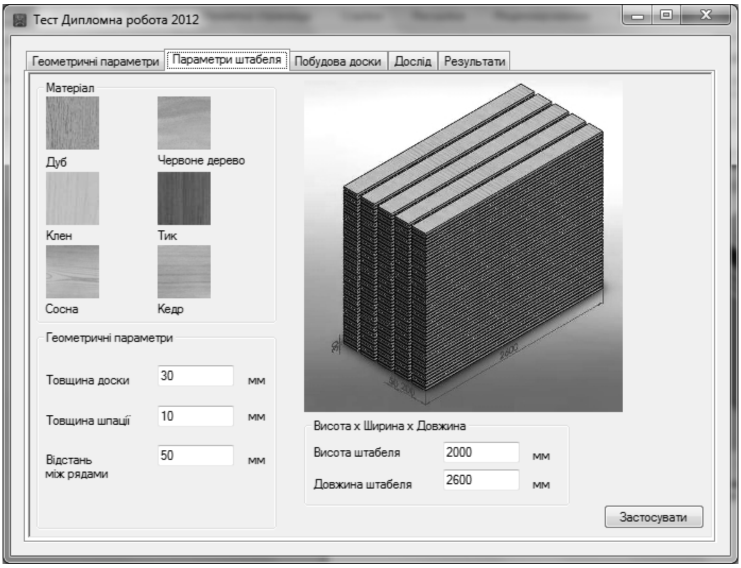


Fig. 9. The interface of the inset «Parameters of the stack»

In Fig. 9 we can see that the stack parameters of the wood are taken into account, in particular: material, the thickness of a board, the sickness of spacing (between boards in the stack), the distance between rows of boards, the height of the stack, the length of the input board.

In the following insets it is possible to set input parameters for modeling, as well as reflect the findings.

## 5. Mathematical modeling of the forest drying chamber object by means of COSMOSFloWorks

After the 3-D model of the chamber has been fully designed in Solid Works medium, it is possible to begin the computer-aided calculation of physical fields in the forest drying chamber.

However, the more there are surfaces and objects in the calculation area, the more hardware resources will be required for the calculation. In order to economize on these factors, a simplified model of the chamber has been developed, on the basis of which calculations have been conducted. For the beginning of the computer-aided calculation it is necessary to create a design in COSMOSFloWorks, set input data, as well as initial and boundary conditions. Therefore, the following steps have been taken in COSMOSFloWorks:

- as usual, first of all setting the name of the design;
- choosing a unit of measurement system. In our case it is the system SI. For convenience, we change the temperature indication from K to °C;
- choosing a problem type: either internal or external. An internal problem is the sawn timber change calculation in a stack. And an external one is the chamber drying agent parameters modeling which influence on the internal problem solution;
- choosing a substance type inside the model. In our case it is Air;
- choosing materials for details included into our assemblage. There is no wood in a standard library of COSMOSFloWorks. Therefore, there have been created and added to the database such materials as: maple, oak, pine, mahogany, teak and cedar;
- the next step is setting the surfaces thermal-physical parameters of the model. For example, coefficients of thermal conductivity, initial temperature of external air and other characteristics;
- setting thermal-physical and aerodynamic parameters of radiators and ventilators;
- defining the accuracy of the findings. Therefore, we take advantage of the created irregular grid for the method realization of the finite elements.

As soon as the design is created, it is necessary to insert corresponding input data in the control bar of FloWorks, in particular: pressure (static) — 101325 Pa, initial temperature of air in a chamber — 20°C and other parameters. Heating of air is realized by radiators in a chamber. We install their capacity: approximately 2 kW. Air flows are sent under the action of axial ventilators in the direction of radiators with the angular velocity of 100 r/s. It is also necessary to set physical parameters of the chamber elements and thermal conductivity. It is vital to indicate that the integration of COSMOSFloWorks with SolidWorks is required for such an approach. It permits to conduct the computer-aided calculation of the researched physical fields in the forest drying chamber without additional lines of the data transfer between the program coverings of the object geometric design and mathematical modeling, as well as calculation. The tasks of the data-in and the visualization are realized directly in the medium of SolidWorks.

## 6. The analysis of the findings

The computer-aided calculation system COSMOSFloWorks can receive results in graphics what makes them more available and comprehensible. In its turn the developed supplement enables to research variants as much as possible due to the change of input parameters for each new research.

In Fig. 10 there is represented the inset which reflects the findings of the experiment modeling.

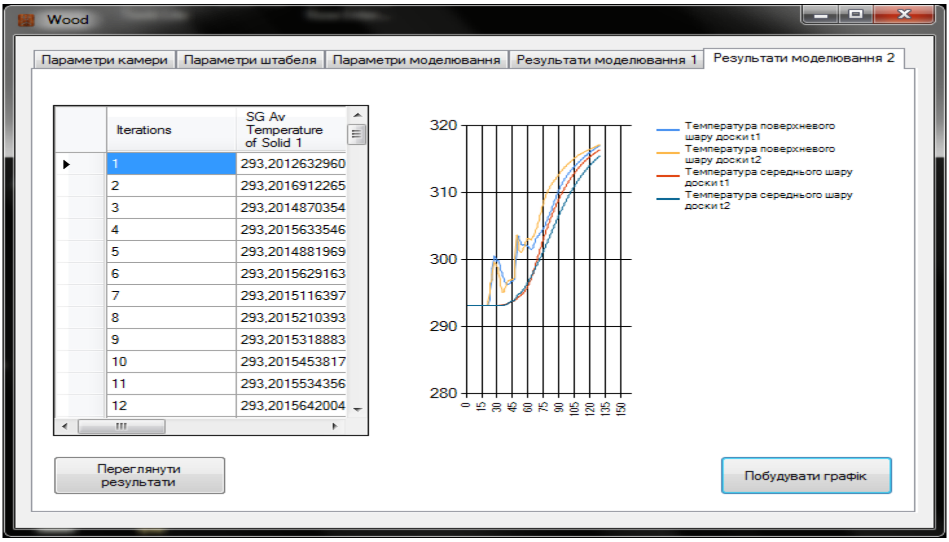


Fig. 10. The result of conducting the experiment modeling

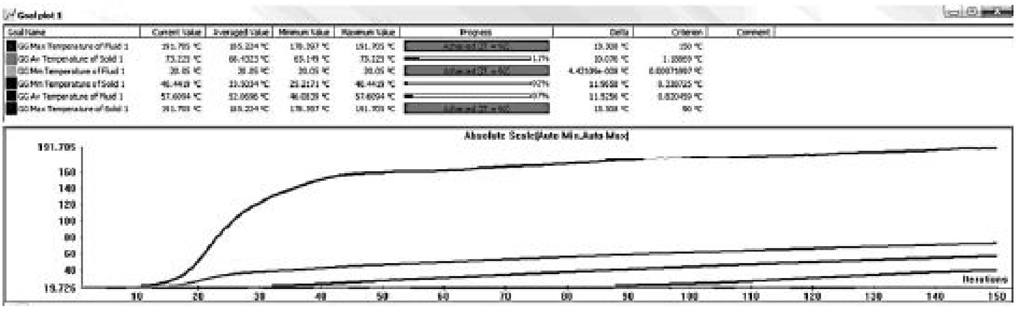

Fig. 11. Interim temperature denotations results concerning the time of research conducting

During the modeling process of forest drying chamber elements work it is possible to observe the temperature change in a chamber with every calculation iteration in real-time.

In the upper part of Fig. 11 there are demonstrated denotations of all the parameters which we have set as the goals of the calculation. And in the lower part they are illustrated graphically. In the diagram we can trace the air and chamber surfaces temperature change caused by the heating of the radiator. Initial air temperature forms 20 °C inside the chamber. With the time flow it begins to grow, after it surfaces temperature starts to grow as well. After the 20 time units mark we can observe the way air temperature rapidly goes up (it is connected with the mixture of heated steams and air which reached the chamber) and the stack surface temperature rises as well but fluently and gradually.

COSMOSFloWorks enables to research corresponding parameters in necessary chamber spots and in any moment of time. The system also emits results for other researched parameters, such as speed, pressure, density, flows intensity.

**Conclusions.** The possibilities of SolidWorks API, COSMOSFloWorks application for 3-D design of the forest-drying chamber in the process of wood drying have been demonstrated. In particular, in research:

- the 3-D model of the forest drying chamber and its components have been developed;
- there have been set the input parameters for the modeling: parameters of radiators and ventilators, air temperature inside and outside the chamber, air pressure, characteristics of chamber materials and objects in it;
- the wood drying process, in particular the distribution of air and thermal steams in the chamber and wood have been modeled;
- the modeling findings in both numerical and graphic form have been received and analyzed.

The great contribution of the interface SolidWorks API is worth taking into account due to which the program system for the modeling conducting of interactive experiments has been developed, as well as a quite simple and convenient in usage graphic interface for a user which permits to take advantage of all the functions of the given system.

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## Автоматизоване проектування та дослідження засобами SolidWorks API та COSMOSFloWorks камер сушіння деревини

Ярослав Соколовський, Ірина Борецька, Петро Рожак

*Здійснено тепловий розрахунок та аналіз фізичних потоків у лісосушильній камері з використанням інформаційних технологій проектування COSMOSFloWorks. Для твердотілого моделювання лісосушильної камери та створення тривимірних моделей її компонентів використано систему автоматизованого проектування SolidWorks 2011.Розроблено та реалізовано програмно-орієнтований комплекс «Wood v.1.0» на основі SolidWorks API, з використанням компілятора Microsoft Visual studio 2010, який дає можливість досліджувати параметри камери, а також керувати геометрією лісосушильної камери та штабеля.*

## Автоматизированное проектирование и исследование средствами SolidWorks API и COSMOSFloWorks камер сушки древесины

Ярослав Соколовский, Ирина Борецкая, Петр Рожак

*Осуществлено тепловой расчет и анализ физических потоков в лесосушильной камере с использованием информационных технологий проектирования COSMOSFloWorks. Для твердотельного моделирования лесосушильной камеры и создания трехмерных моделей ее компонентов использована система автоматизированного проектирования SolidWorks 2011. Разработан программно-ориентированный комплекс «Wood v.1.0» на основании SolidWorks API, с использованием компилятора Microsoft Visual Studio 2010, который позволяет исследовать параметры камеры, а также управлять геометрией лесосушильной камеры и штабеля.*

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