

THE USING COMSOL MULTIPHYSICS ENVIRONMENT IN SOLVING TECHNICAL PROBLEMS

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Abstract. The aim of investigation is an analysis of mathematical models of real physical and technical processes among Comsol Multiphysics. The objective of the study is to implement the models described by differential equations second order partial derivatives. The object is Comsol Multiphysics environment and its features in solving various problems, and the subject is the main types of differential equations of mathematical physics. The study used basic approaches and methods for modeling physical and technical processes and computer experiment. The research is numerical solutions of mathematical models considered processes that describes the relevant differential equations of mathematical physics. Models that are created among Comsol Multiphysics are used in teaching and scientific process of higher education [1].

Key words: differential equations of mathematical physics, Comsol Multiphysics environment, finite element method, triangulation geometry.

ВИКОРИСТАННЯ СЕРЕДОВИЩА COMSOL MULTIPHYSICS ПРИ РОЗВ'ЯЗАННІ ТЕХНІЧНИХ ЗАДАЧ

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Анотація. Метою дослідження є аналіз математичних моделей реальних фізико-технічних процесів у середовищі Comsol Multiphysics. Завданням дослідження є реалізація моделей, які описуються диференціальними рівняннями другого порядку в частинних похідних. Об'єктом дослідження є середовище Comsol Multiphysics та його особливості при розв'язанні різного роду задач, а предметом – основні типи диференціальних рівнянь математичної фізики. У дослідженні використані основні підходи та методи моделювання фізико-технічних процесів і комп'ютерного експерименту. Результатом дослідження є чисельні розв'язки математичних моделей розглянутих процесів, які описуються відповідними диференціальними рівняннями математичної фізики. Моделі, які створені у середовищі Comsol Multiphysics використовуються у навчально-науковому процесі вищого навчального закладу [1].

Ключові слова: диференціальні рівняння математичної фізики, середовище Comsol Multiphysics, метод скінченних елементів, триангуляція геометрії.

Introduction. Today there are many math packages that resolve technical problems in different areas of science and technology. These packages include MatLab, MathCad, Maple and others. Every medium has its advantages and disadvantages. In solving technical problems by built libraries it often uses Comsol Multiphysics environment. The main advantages of this environment include: description of the geometry of the object of arbitrary shape, using finite element method, speed and efficiency to obtain the numerical solution of the problem. Note that Comsol Multiphysics uses different methods of triangulation area [1]. The process of triangulation is one of the main components of the environment, as studied real objects of nature, as has been said, can be of any geometric shape. Models that can solve Comsol, in the vast majority, are described by second-order differential equations in partial derivatives.

The purpose of the work. The study is the implementation of models of real technological processes, which are described by equations of mathematical physics, among Comsol Multiphysics.

Formulation of the problem. To study the main features of the environment have been solved different tasks for each type of differential equations of mathematical physics.

Parabolic equation. Find a solution to the following problem:

$$\frac{\partial T}{\partial t} = \frac{\partial^2 T}{\partial x^2}, \quad x \in [-1; 1], \quad t \in [0; 5],$$

initial condition:

$$T(x; 0) = (x - 2)(1 - x),$$

boundary conditions:

$$\left. \frac{\partial T}{\partial x} \right|_{(-1; t)} = 0, \quad \left. \frac{\partial T}{\partial x} \right|_{(1; t)} = 1,$$

internal condition:

$$T(0.5;t) = 1.$$

Hyperbolic equation. Find a solution to the following problem:

$$\frac{\partial^2 T}{\partial t^2} = \frac{\partial^2 T}{\partial x^2}, \quad x \in [-1;1], \quad t \in [0;5],$$

initial conditions:

$$T(x;0) = T_t'(x;0) = 0,$$

boundary conditions:

$$\left. \frac{\partial T}{\partial x} \right|_{(-1;t)} = 0, \quad \left. \frac{\partial T}{\partial x} \right|_{(1;t)} = 1,$$

internal condition:

$$T(0;t) = 10^{-1} \sin 6\pi t.$$

Elliptical equation. Find a solution to the following problem:

$$\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} = 1, \quad (x; y) \in [-1;1]^2,$$

boundary conditions:

$$\left. \frac{\partial T}{\partial x} \right|_{(-1;y)} = 0, \quad T(1;y) = 1, \quad \left. \frac{\partial T}{\partial y} \right|_{(x;-1)} = 0, \quad T(x;1) = 1,$$

internal condition:

$$T(-0.9;-0.9) = T(0.9;-0.9) = T(-0.9;0.9) = T(0.9;0.9) = 3.$$

Solving problems. To solve the tasks area (geometry) is constructed, where the problem is solved. After building area triangulation is performed. Based on the triangulation area, the system of algebraic equations given boundary and initial conditions is formed. The environment includes advanced methods and algorithms for working with sparse matrices, allowing fast enough to get the result. Comsol solves both linear and nonlinear problems. During the work with environment, technical problems, which mathematical models are given above, were solved. Comsol Multiphysics very effectively copes with the set technical problem. Move on to solving the above problems (figure 1-4).

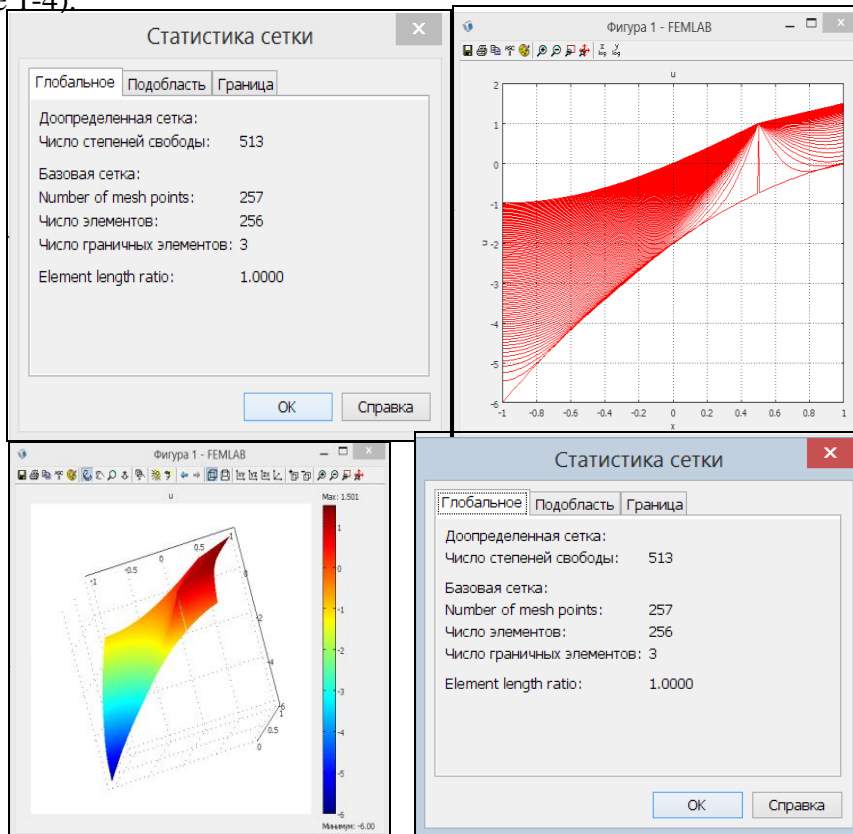


Fig.1. Result solving first task:
left – settings geometry grid; middle – time solution; right – surface.

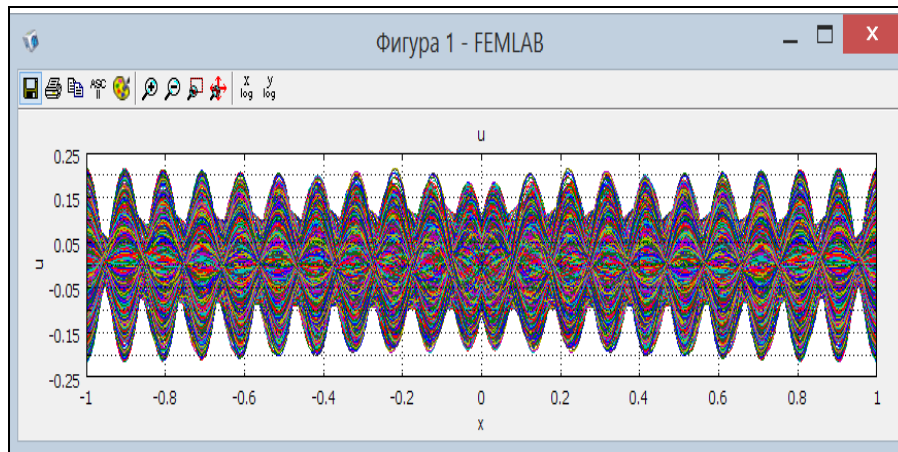


Fig. 2. Result solving second task:
left – settings geometry grid; right – time solution.

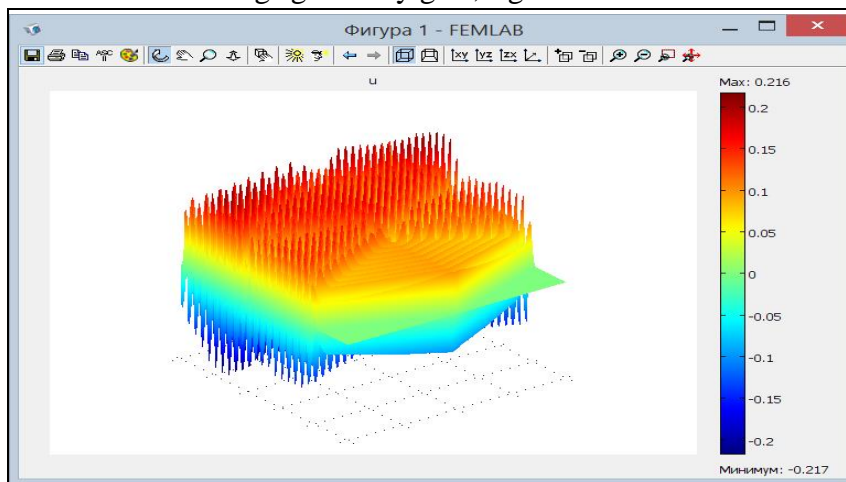


Fig. 3. Result solving second task. Surface.

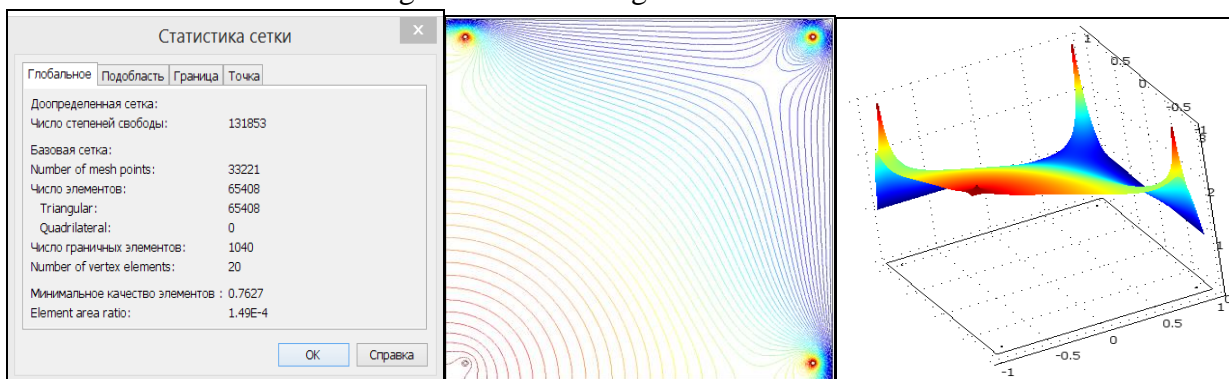


Fig. 4. Result solving third task:
left – settings geometry grid; middle – contour plot; right – surface.

Conclusions. Based on the results, we can say that Comsol Multiphysics environment is quite powerful tool with the help of it we can solve a wide range of physical and technical problems of different origin. Considered environment quickly and effectively copes with the task. It should also be noted that the problems, which were solved, have the internal conditions. In terms of real objects such problems occur frequently in everyday life.

References

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