MATHEMATICAL MODELLING IN NATURAL SCIENCES AND INFORMATION TECHNOLOGIES

PROBLEM OF CONVECTIVE HEAT CONDUCTIVITY OF A DOUBLE ENVIRONMENT UNDER HEAVY BORDER CONDITIONS

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Abstract

In this paper, we consider the special cases of the application of the method of finite integral transformations in the problem of convective heat conductivity of a two-layer medium. In this case inhomogeneous boundary conditions of the first kind in any form are given at external boundaries. It is shown that after carrying out the integral transformation, the formal solution is written in the form of functional series with nonuniform convergence. This leads to difficulties in the numerical solution of the problem. Especially large errors occur when calculating the temperature function near the outer boundaries and common interfaces of the layers. The main idea of this research is obtaining a solution in the form of rapidly converging series.

The physical definition of the problem can be found below. We consider a two-layer medium. Heat is distributed according to the laws of heat conduction and convection. On the outer boundaries, non-homogeneous boundary conditions of the first kind in common form are given. At the common interface of the layers - the conditions for an ideal thermal contact. At the initial moment of time, the temperature of the layers is represented as an arbitrary function of the spatial variable. The temperature function is determined, which depends on the spatial variable and time. The mathematical model consists of a one-dimensional nonstationary heat conduction equation with a convective component, boundary conditions and initial conditions.

It is shown that it is necessary to represent the target temperature function in the form of a sum of two terms: nonstationary and quasi-stationary. An algorithm for solving the problem with respect to the quasi-stationary component is given. Its final representation is written in the form of a linear combination of linear and exponential functions. The analysis of the obtained solution is carried out. It is concluded that taking into account the quasistationary term makes possible to improve the convergence of the functional series representing the formal solution of the initial problem for inhomogeneous boundary conditions.

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EFFECTIVE METHOD OF OPTIMIZATION IN A LINEAR MATERIAL CUTTING

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Abstract

In this paper the problem of one-dimensional cutting is considered, which has practical application, for example, on the majority of enterprises for the production of double-glazed windows and related enterprises (production of windows, balconies, doors, partitions, etc.). The problem of this industry lies in the fact that a large number of construction companies, using cutting algorithms, which lack an optimization component, are present on the market, and scientific research in this field has been focused on specific modern production tasks.

There are many approaches for solving the problem, a thorough analysis of each of which gives its own ways and means to save materials, but often the proposed solutions are either highly specialized or generalized. The urgent task is to create more effective optimization algorithms for solving a cutting task.

In the paper, issues of classification of rational cutting and packaging problems were considered. The general scheme of classification of problems of this type is given, mathematical models of this class of problems are considered.

The problem of rational decomposition belongs to the class of NP-complete discrete optimization problems of the combinatorial type. An overview of the methods for solving problems of this type, which arise in the production with the implementation of linear cutting of dimensional material, is performed. The scheme-classification of approaches to the solution of the problem of cutting-packing is made.

An effective method for solving complex problems of linear cutting is proposed, based on the method of exact quadratic regularization (EQR). The EQR method has an algorithmic basis, therefore, in the presented classification, was attributed to algorithmic methods.

The EQR method has shown far better results in solving many of the test multi-extreme problems compared with existing methods. The same is what we observe when solving problems of linear cutting of materials. Examples are given of the solution of the linear cutting problem using residues.

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IMPLEMENTATION OF SOME PROBLEMATIC OPERATIONS IN SYSTEMS OF RESIDUAL CLASSES

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Abstract

Computing structures are constantly being demanded to improve performance. The use of the residual class system when performing arithmetic operations of addition, subtraction and multiplication makes it possible to improve the performance of such systems through natural parallelization of data processing. The merits of this representation of numbers also include the low-quality residuals, high accuracy and reliability, the ability of the system to self-correction. The aim of the research is to analyze analytically the system of residual classes with pairwise mutually simple modules and the residual class system with all even modules for implementing the basic problem operations of determining the number of a given half of the range and comparing numbers. It is shown that in the first case the representation of numbers in a polyadic code with the same set of modules as in the remainders of these modules is the only one. This makes it possible to realize the operation of determining the membership of a number in the given half of the range and, on its basis, the operation of comparing numbers. Algorithms for performing these operations are given. It is also shown that in the second case, the representation of numbers in a polyadic code with the same set of modules as in the remainders of these modules is not the only one, and therefore the search for a solution to the basic problem operations discussed above requires further research. The algorithm for comparing numbers in a system of residual classes with all even modules by an algorithm not based on the determination of the number of first or second half of the range is given, and the realization of the comparison of numbers by this algorithm is considered.

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NUMERICAL SIMULATION OF BIOLOGICAL WASTEWATER TREATMENT IN AERATION TANK

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Abstract

Aeration tanks are widely used in practice for wastewater treatment. Prediction of aeration tank efficiency under different regimes of eploitation needs quick computing mathematical models. Nowdays there is lack of such models.

The goal of this work is development of operational model which is based on the fluid dynamic model and equation of mass transfer. The flow field in the aeration tank is simulated on the basis of potential flow model. 2-D transport equations are used to simulate substrate and sludge dispersion in aeration tank. To simulate the process of biological treatment simplified model is used which takes into account the process of sludge growth and substrate extinction. For the numerical integration of transport equations implicit difference scheme was used. The difference scheme is built for splitting transport equations. Splitting of transport equation into two equations is carried out at differential level. The first equation of splitting takes into account the sludge or substrate movement along trajectories. The second splitting equation takes into account the diffusive process of substrate or sludge. To solve the splitting equations implicit difference scheme was used. For the numerical integration of potential flow equation the implicit scheme of conditional approximation was used. On the basis of constructed numerical model computer experiment was performed to investigate the process of biological treatment in aeration tank. The numerical experiment was carried out for the comprehensive regime of work which includes two stages. At the first stage the process of biological treatment was considered. At the second stage we considered the process of biological wastewater treatment together with sludge and substrate flow.

Proposed numerical model can be used to obtain aeration tank parameters under different regimes of work. The model developed takes into account the geometrical form of the aeration tank.

The future work in this field will be connected with development of fluid dynamics model which takes into account oxygen transfer in the aeration tank.

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THE JUSTIFICATION FOR SELECTION OF NUMERICAL METHOD FOR MELTING PROBLEM SOLUTION OF WEIGHTED COMBINED ALUMINUM-CONTAINING DEOXIDIZER OF CYLINDRICAL FORM IN PROTECTIVE SHELL

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Abstract

This paper presents a comparative analysis of numerical calculation methods for model problem of prismmeltingunder asymmetric boundary conditions to substantiate the choice of the numerical method for solving the melting problem of a weighted combined aluminum-containing deoxidizer of cylindrical form in a protective shell in the melt and under asymmetric boundary conditions at the slag-metal interface.

The melting problem of a weighted combined aluminum-containing deoxidizer of cylindrical form in a protective shell relates to the problems of thermal conductivity with movable interfaces.

The aim of the article is to compare the method of Duzimber used for this problem and the more well-known Nikitenko method (a method with explicit boundary separation) that has been successfully applied to solve similar problems and is confirmed by numerous laboratory experiments. The data for comparison were taken from the solution of the model prism melting problem under asymmetric boundary conditions.

Data analysis shows that the divergence between the calculation results does not exceed 10 percent and decreases significantly as the difference grid thickens. Thus, the adequacy of the developed algorithms and the results of melting calculation of weighted combined aluminum-containing deoxidizer of cylindrical form in a protective shell on the basis of the Duzimber method is confirmed by a good agreement between the calculation results of model problem of prism melting under asymmetric boundary conditions by Nikitenko and Duzimber methods, and the latter has a much simpler algorithm.

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