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The Technology of Calculating the Optimal Modes of the Disk Heating (Ball)

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Abstract

The paper considers the problem of optimal control of the process of thermal conductivity of a homogeneous disk (ball). An optimization problem is posed for a one-dimensional parabolic type equation with a mixed-type boundary condition. The goal of the control is to bring the temperature distribution in the disk (ball) to a given distribution in a finite time. To solve this problem, an algorithm is proposed that is based on the gradient method. The object of the study is the optimal control problem for a parabolic boundary value problem. Using the discretization of the original continuous differential problem, difference equations are obtained for which a numerical solution algorithm is proposed. Difference approximation of a differential problem is performed using an implicit scheme, which allows to increase the speed of calculations and provides the specified accuracy of calculation for a smaller number of iterations. An approximate solution of a parabolic equation is constructed using the one-dimensional sweep method. Using differentiation of the functional, an expression for the gradient of the objective functional is obtained. In this paper, it was possible to reduce the multidimensional heat conduction problem to a one-dimensional one, due to the assumption that the desired solution is symmetric. A formula is obtained for calculating the variation of a quadratic functional that characterizes the deviation of the current temperature distribution from the given one. The flowcharts and implementations of the algorithm are presented in the form of Matlab scripts, which clearly demonstrate the process of thermal conductivity and show the computation and application of optimal control in dynamics.

Keywords: Optimal Control; Parabolic Equation; Gradient Method; Software Complex for Calculating Optimal Modes.

1. Introduction

Optimization problems are found in almost all spheres of human activity, since any activity must be effective in a certain sense. That is, an action plan must be chosen that ensures optimality, according to the chosen criterion. The search for optimal solutions led to the creation of special mathematical methods and the mathematical foundations of optimization (calculus of variations, numerical methods, etc.) were laid already in the 18th century. However, until the second half of the 20th century, optimization methods were used very rarely in many areas of science and technology, since the practical use of mathematical optimization methods required tremendous computational work, which was extremely difficult to implement without a computer, and in some cases impossible. If we do not take into account the economic, physical, chemical or other content of these tasks, then all tasks are reduced to the following optimization problem: to find the minimum (or maximum) of a function or functional on some admissible set of a given functional

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