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OPTIMIZATION AND MANAGEMENT OF MULTILAYERED SYSTEMS

The report is devoted to the issues of calculation and optimization of multilayer biotechnological systems containing concentrated, local, discrete sources of thermal loads. The paper presents one of the possible approaches of the implementation of the optimization parameters of such systems. Having emphasized the research on the mathematical modeling of multilayer objects of complex geometry with the presence of prohibition zones on the movement of fission paths, the author encounters difficulties in setting up and implementing computational and applied optimization mathematical models. To overcome them, it becomes necessary to solve the non-classical problem of non-linear mathematical programming of a special kind. The relevance of the issues examined is mentioned in the works [1–3]. On solving the optimization problems of the systems under consideration, the author obtained the following scientific results.

1. The mathematical model of the main optimization problem has been improved, which is a multidimensional, non-stationary, non-linear and multi-extreme problem of optimizing the parameters of the process of laser local thermal exposure. The characteristic features of the mathematical models of applied optimization problems are investigated, which made it possible to justify the choice of the methods for their numerical and hardware-software implementations.

2. For the first time, a multi-point boundary-value problem for a multilayer microbiological medium has been investigated and the correctness of such a problem with small perturbations has been proved. To this end, the author has proposed a method for studying the Cauchy problem for a system of perturbed pseudo-differential equations, on the basis of which the correctness conditions for this problem are determined, and also it is found out which pseudo-differential operators can perturb the right-hand side of the main equation of the boundary-value problem so that it remains correct. The obtained results allow us to apply the above method to determine and prove the correctness conditions for the boundary-value heat conduction problem in spherical coordinates, which underlies the calculated mathematical model for spherical biomaterial with inhomogeneous inclusions. This makes it possible to guarantee the existence and uniqueness of a solution to the considered boundary value problem.

Based on this, it was concluded that the boundary-value problem under consideration is correct in spaces of generalized functions with sufficiently small perturbations. This made it possible: justification of the adequacy of the calculated mathematical models describing the process of the action of the laser beam on multilayer microbiological materials; guaranteeing the adequacy of applied optimization mathematical models.

3. The search method for optimizing the vector of thermal effects parameters has been improved, based on the composition of sequentially applied numerical methods forming a computational structure. A block diagram of the basic algorithm for the implementation of the computational structure is proposed. The universality of the structural scheme enables it, without significant changes and additions, to be used for the numerical implementation of various applied mathematical models related to the optimization of systems “multilayer material – a source of thermal action”. This, in turn, allows for their numerical implementation to change only the composition of numerical methods in the corresponding computational structures.

Stating a basic algorithm for optimization of the objective function parameters, which consists of input of output data: spatial form of microbiome; geometric dimensions of microbiome; microbiome sampling steps; coefficients included in the formulation of the original boundary value problem; parameters of the computational process for the numerical realization of the boundary value problem; parameters of the computational process for the numerical implementation of the step-by-step optimization method; criteria for stopping the search for local extremum and the search for local extrema.

The following is the first approximation of the components of the vector of thermal influence parameters. This initial information can be generated on the basis of expert evaluation of the results of the use of such laser technology and consistent with the capabilities of existing technical means.

Futhermore, the analysis of the implementation of a given system of constraints on the components of the vector of parameters of thermal influence is carried out. If the parameter limits are not fulfilled, then the original values of the thermal influence parameters are returned to the previous block and the process is repeated. If the constraints are met and the technical means allow us to set these parameter values, then we proceed to the next block of the corresponding boundary value problem. To do this, based on the predefined initial data, a boundary value problem is formed and solved, which describes the temperature field in microbiome when exposed to a laser beam. Next, in accordance with the type of objective function of the mathematical model of the optimization problem, the local extrema of the objective function are searched and analyzed. The obtained values of local extrema are analyzed according to a predetermined criterion for termination of the search process for the search of local extrema. If the corresponding criterion is fulfilled, then the optimization process is terminated and the record value of the objective function, as well as the corresponding record vector of rational parameters of thermal influence of the laser on microbiome, is fixed at the output. If the criterion for termination of the search process for the search of local extrema is not fulfilled, then the task (correction) of

the new values of the parameters of the laser influence is carried out, and then the computational process is repeated.

The obtained results allowed the author, with the hardware implementation of applied optimization problems, through the use of functionally oriented blocks to increase their accuracy. The latter is due to: the absence of the development stage of the corresponding software; parallel execution of certain stages of the algorithms; the use of analog blocks, which almost instantly simulate the thermophysical processes occurring in a multilayer microbiological material when exposed to a laser beam. The mathematical models developed by the author, numerical methods, and hardware and software allow to: automate the interdisciplinary study of both mathematical models and the process of interaction of laser radiation with multilayer microbiological material.

The obtained results can be applied to: improvement of the quality of the process of division of artificial and genuine skin in the treatment of major burns; diseases of biomaterials; division of early elite embryos for the purpose of subsequent transplantation of embryo parts, the usage in the practice of microsurgery, ophthalmology, cosmetology and other fields.

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МОДЕЛИРОВАНИЕ СЛОИСТЫХ ГРУНТОВ В ГЕОРАДАРНЫХ ИЗМЕРЕНИЯХ

Интерпретация результатов георадарных измерений является сложной задачей. Это связано, прежде всего, с отсутствием общей теории решения как прямых, так и обратных задач электромагнитного рассеяния в неоднородных нелинейных средах с объемным характером рассеяния зондирующего сигнала. Поэтому рассматривают, как правило, ее упрощенные варианты. В частности,