Mathematical Modelling and Analysis
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MATHEMATICAL MODELLING IN ELECTROTECHNICS

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The paper emphasizes advantages of the method integral equations (MIE) in various branches of technology, with special attention paid to large sense of power engineering. These problems usually lead directly to integral equations types or integro-differential equations. The numerical methods for a general class of integral equations in space-time (Volterra-Fredholm integral equations) will be presented, to which power engineering problems including time-dependent models may be reduced. We restrict to some integral mathematical models in electrotechnics. The report analyses the methods of numerical solution of various tasks defined in the terms of boundary-initial value problems of differential or integral equations. In general in natural and technical sciences a mathematical model is defined by differential equations dealt mostly with: finite-difference method (FDM),finite-element method (FEM),boundary-element method (BEM).

A choice of calculation method is affected by many factors. First of all, it is determined by the possibility of accurate definition of the problem, inclusive of its formulating and regard to boundary-initial conditions. It depends as well on the system of algebraic equations and parameters of computer hardware used for carrying out the task.

The FDM is the oldest, the simplest, and the most popular method, based on replacing finite differences for derivatives. It was formulated as an approximate discrete method for solving boundary-value problems defined in terms of differential equations. Furthermore, its application was widened to variational problems. It may be used as well for boundary-initial value problems related to differential equations of parabolic type, describing temperature distribution in the theory of heat conduction. Therefore, it is usually applied to internal problems. It might be also used for external problems but leads to huge systems of equations, as the elements must cover the whole field of analysis.

Recently a BEM approach is very often used for mechanical problems. It is conducive to considerable reduction of the number of equations. It appears very advantageous, as for solving of great number of equations a computer of great memory size is required and the process itself is much labor-consuming. Success of the method consists in omitting of discretization of the field. Only its border is subject to discretization, causing reduction of the size by unity and lowering the computation time. The FEM and BEM approaches might be considered as complementary as their faults and advantages compensate each other. Extensive work aimed at connecting of both methods lead to hybrid technics joining advantages of both and eliminating their faults.

Unfortunately, the above mentioned methods are rather useless for determining of voltage gradients distribution in electro-insulation systems. The integral equation method (IEM) seems to be the most appropriate for this purpose, as electric potential distribution is described with the help of integral equations. Such formulation of the problem, inclusive of boundary conditions (potentials for the conductors or their total charges) leads to a system of integral equations the numerical solution of which enables determining of charge density distribution of conducting parts and potential distribution in surrounding space.

The work presents advantages of the method of integral equations (IEM) and possibility of its application to various branches of technology, particularly to the problems arising in comprehensively understood power engineering. It is an analytical-numerical method and requires deep engagement of highly skilled specialists (mathematicians, specialists of numerical and computer sciences, engineers).

Taking into account growing popularity of integral equations, the present paper is devoted to the most modern methods of numerical solving of wide class of integral equations in space-time, called the Volterra-Fredholm equations. It should be noticed that the algorithms provided here may be in particular applied for integral equations of both Volterra or Fredholm types.

In this paper we restrict to mathematical models in the current density theory and the heat conduction theory.