

Inductively Heated Incompressible Flow of Electrically Conductive Liquid in Pipe

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A novel computer model of inductively heated incompressible flow of electrically conductive liquid in a pipe is presented. The numerical solution of the coupled problem is realized by a higher-order finite element method using the variational formulation developed and verified by the authors. The algorithm contains a number of original features such as lumping nodes of one order or in time when discretized by a regular complete-wave method on discontinuous periodic time-dependent field variables. The methodology is illustrated by a typical complete-wave method on discontinuous periodic time-dependent field variables. The methodology is illustrated by a typical complete-wave method on discontinuous periodic time-dependent field variables. The methodology is illustrated by a typical complete-wave method on discontinuous periodic time-dependent field variables.

Index Terms: Electrodynamics, Inductive heating, Incompressible flow, Induction heating, Numerical solution, Temperature field.

1. INTRODUCTION
NUMERICAL methods in electrical engineering working with electrically conductive liquids (e.g., molten metals, molten salts or electrolytes) are based on the finite and infinite elements of electrodynamics. We use the finite element method, finite difference method, and other similar processes. The computer modeling of such processes is still a challenge. These tasks usually represent multiply coupled nonstationary and often nonlinear problems, characterized by interaction of several physical fields. The flow itself can be accompanied by turbulent and/or laminar phenomena that are difficult to model using finite element methods. In the past, the numerical modeling of such problems in the domain showed, see e.g. [1], [2], a lot of tasks were solved only partially or still remain unsolved.

The paper deals with the problem of heating a conductive liquid flowing in a pipe velocity in a magnetic field. The numerical solution is carried out unlike former classical finite element and finite difference methods by our novel higher-order finite element method (HOFEM).

2. FINITE ELEMENTS ON THE PROBLEM
Consider the arrangement depicted in Fig. 1. The figure shows a vertical pipe with electrically conductive liquid that flows from the left to the right and is both heated up by a time-varying magnetic field generated by a horizontal current-carrying inductor and accelerated by the corresponding Lorentz forces. The arrangement of the system is assumed axisymmetric. The task is to map the time evolution of all physical fields in the system: magnetic field, temperature field, field of the fluid and mechanical properties of the liquid, pipe and inductor as supported by the known, as well as the relevant initial and boundary conditions, and also the parameters of the field current in amplitude I and frequency ω .

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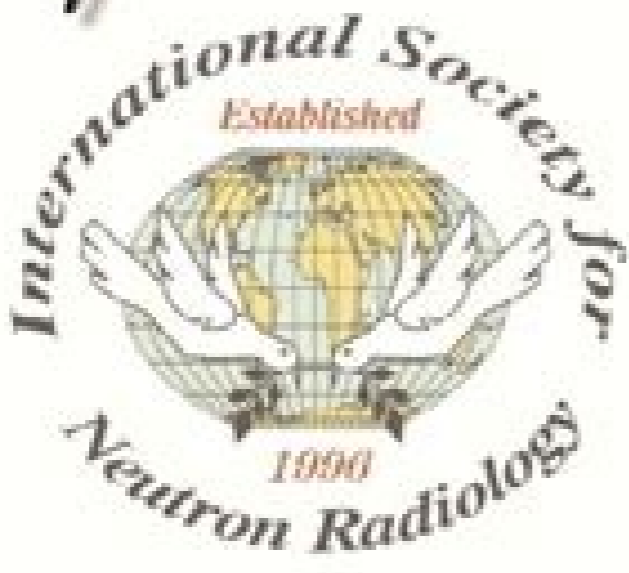
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