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OPTIMIZATION OF INDUCTION HEATING SYSTEMS BY A COUPLED THERMAL-ELECTRICAL FEM MODELLING

Mariusz A. Stepien, Marcin Kasprzak

Department of Power Electronics, Electrical Drives and Robotics, Faculty of Electrical Engineering
The Silesian University of Technology, B. Krzywoustego 2, 44-100 Gliwice, Poland, re5@polsl.pl,
http://kener.elektr.polsl.pl/

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Abstract. Induction heating processes are very sensitive on numerous parameters and coefficients of the system, including geometry and structure of materials, shape and size of the inductor, parameters of energy generator. So, optimization of design of inductions systems requires sophisticated analysis and interdisciplinary approaches. The paper describes methods and example analyses devoted for induction heating and resistance spot welding where coupled thermal-electrical FEM analysis has been carried out. Results are discussed and referred to experimental results. The most important aspects discussed in the paper are: the mesh density definition, employing the object symmetry in model selection and definition of material parameters (including nonlinearities and temperature dependence). Preparation of FEM model for analysis of induction heating processes requires definition of proper density of mesh. The density depends mostly on geometry and on process parameters (mostly frequency). The finest mesh is required on surfaces of heated material, where attenuation of magnetic field is the highest. Finally the mesh density produces large number of finite elements. It means that reasonable calculations of induction heating problems are possible for 2D models. So, the second considered issue is simplification of geometry including employing of planar or axial symmetry into modelling. Modelling of induction heating is a coupled thermal and electromagnetic problem, so proper calculation requires definition of materials in range of thermal and electromagnetic properties (usually as a function of temperature). Finally, in order to ensure proper influence of temperature on electrical properties the time steps should be defined taking into account time constants of thermal and electrical properties. The paper will include discussion of above described models and examples of modelling with discussion of results.

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